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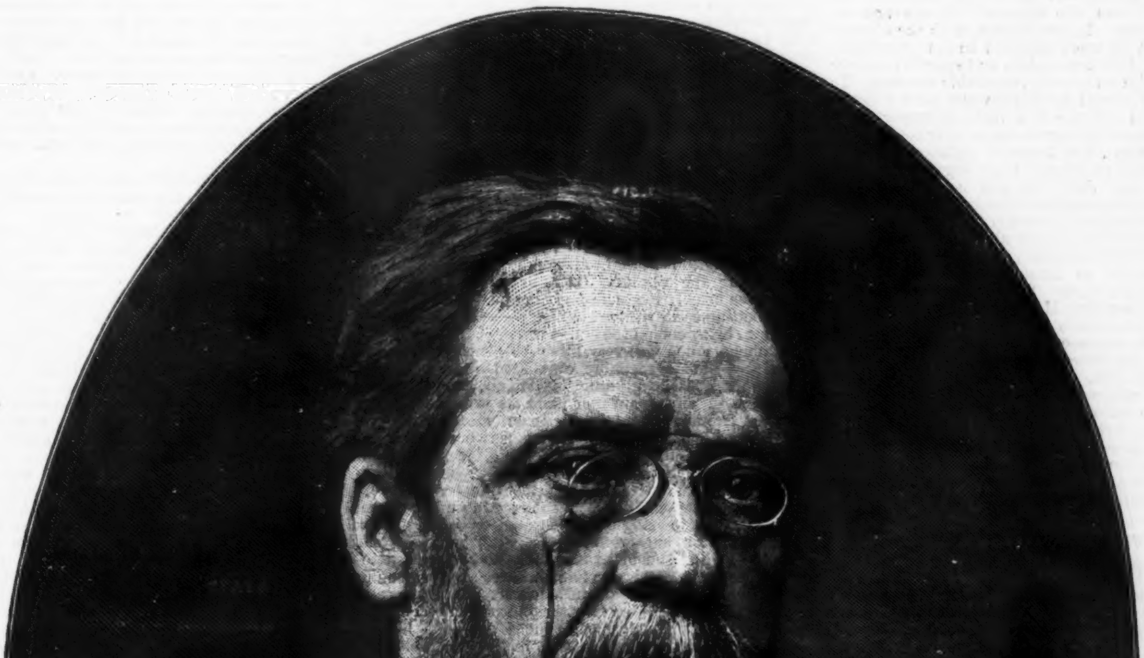
LOUIS PASTEUR.

M. **Louis Pasteur**, the noted French chemist, was born at Dole, Dec. 27, 1822, and belongs to that hardy race that has given France Victor Hugo, Charles Nodier, Fourier, Proudhon, and Corbet. Master of the supernumerary studies at the Lyceum of Bensançon at the age of eighteen, he early gave proof of that patience and tenacity of purpose which are the characteristic marks of the Franche-Comté temperament. He took his degree in 1847, was professor of physical sciences at Dijon from 1848 to 1849, and afterward of chemistry at Strasburg till 1854, at which time he organized the new faculty of science at Lille. In 1857 he went to Paris as scientific director of the Normal School. After this he was elected a member of the Institute; and toward the end of 1863 he was appointed to the chair of geology, physical science, and chemistry at the School of Fine Arts; and, subsequently, to that of chemistry at the Sorbonne. He rose to great celebrity, and in 1856 received from the Royal Society of London the Rumford medal, for his researches on the relation of the polarization of light with hemihedrals in crystals, and for other researches. He also received a French prize for his works on fermentation in 1859, and a Jecker prize in 1861 for his chemical labors. In 1873 he was elected an associate member of the Academy of Medicine, and the government granted him in 1874 a pension of 20,000 francs.

M. Pasteur is most widely known from his opposition to the doctrine of spontaneous generation, and his remarkable researches on fermentation. He maintains that all fermentations are processes connected with life, and not of spontaneous origin; and that the living organism must proceed from a parent of the same kind. Fermentation, therefore, can never take place if all access of germs to a fermentable substance is prevented. He has invented a new process for the fermentation of beer, founded upon his theories, a part of which consists in excluding atmospheric air from the fermenting wort, as he holds that fermentation can be conducted without the presence of free oxygen, and, under certain circumstances, proceeds more satisfactorily in an atmosphere of carbonic acid. He discovered that glycerine is one of the products of fermentation. He has also made interesting researches on racemic acid, and has discovered that when racemate of ammonium is mixed with a small quantity of beer yeast, and exposed to a temperature of 85° F., fermentation takes place, and the racemic acid is converted into lævotartaric acid.

In recent years M. Pasteur's name has appeared very frequently in the scientific papers, in connection with his researches on the inoculation of different animals, a process for the prevention of contagious diseases which promises to do for dumb brutes what vaccination has done for man. Many of the author's important papers on this subject have already been printed *in extenso* in the pages of this journal.

On the 7th of July, 1881, M. Pasteur was invested with the Grand Cross of the Legion of Honor, and on the 8th of December of the same year he succeeded M. Littré to a seat in the French Academy, the height of every Frenchman's ambition. Of the Academy of Sciences he has been a member since the year 1862.



LOUIS PASTEUR

M. PASTEUR.

For thirty years M. Pasteur has carried on the most minute and elaborate researches into the lowest forms of life, and his discoveries, in the opinion of many, have established beyond all reasonable doubt the great fact that there is no such thing as spontaneous generation. He is the foremost representative of the "germ theory" of disease, and has absolutely proved in certain departments, and left it a matter of sure inference in others that animal maladies may positively be traced to the presence of minute organisms in the body. There has been fierce controversy on these matters. There still are some vigorous opponents who refuse to be converted, such as Dr. Charlton Bastian, who held debate with M. Pasteur at the Congress last year; but there is no question as to which way the balance of opinion now lies, if, indeed, it is not incorrect to speak of the germ theory as being any longer within the sphere of opinion. The great advance that it has made toward certainty during the last few years is primarily due to the work of M. Pasteur He did not, of course, invent the theory. It is in its outlines as old as the beginnings of scientific medicine; and in a somewhat advanced form it is as old as the last century. But M. Pasteur has given it at once a width and a universality that it lacked before, by his researches into the nature of fermentation and his microscopic studies of disease. It might be thought that beer was too everyday a subject for the investigations of one of the profoundest observers of our time; but M. Pasteur's work on beer has not only made the fortune of the brewers who were wise enough to read him, but has revealed the most important truths as to the mysterious process of fermentation. Wine and silkworms have also attracted his attention; so have chickens and sheep. It was, indeed, with the diseases of these two last that he was concerned in the memorable address last August. Chicken cholera and splenic fever are mysterious and, it had been thought, incurable diseases. To M. Pasteur they have proved neither mysterious nor incurable, for he has found out the two facts, so important in themselves, so immeasurably important in their bearings on all similar diseases, that these forms of sickness are both caused by the presence of minute alien organisms in the body of the animal, and that they can be cured or prevented by a process analogous to vaccination. Vaccination, indeed, which has heretofore been regarded as a certain but inexplicable safeguard in one disease alone, is now in a fair way of being scientifically explained, and, as a consequence, of being proved useful in innumerable cases hitherto thought to be beyond its reach. Some of our readers will remember the statistics which M. Pasteur gave last year of the effects of the vaccination of sheep according to his method. May we not suppose that a similar cure is about to be discovered for the other plagues, whether of human or of lower forms of life, which are one by one being brought within the scope of the germ theory? The researches of Dr. Koch with regard to tubercular consumption, which Professor Tyndall explained in our columns a few days ago, are a case in point. Who can say whether in a few years, or in the next generation, at all events, it may not be the practice to vaccinate for consumption as we now vaccinate for smallpox?—*London Times.*

THE INFINITIES AROUND US.

By Pasteur.

"What is there beyond this starry vault? More starry skies. Well, and beyond that? The human mind, driven by an invincible force, will never cease asking, What is there beyond? . . . It is useless to answer, 'Beyond are unlimited spaces, times, or magnitudes.' Nobody understands these words. He who proclaims the existence of an Infinite—and nobody can evade it—asserts more of the supernatural in that affirmation than exists in all the miracles of all religions; for the notion of the Infinite has the twofold character of being irresistible and incomprehensible. When this notion seizes on the mind, there is nothing left but to bend the knee. In that anxious moment all the springs of intellectual life threaten to snap, and one feels near being seized by the sublime madness of Pascal. Postivism unceremoniously thrusts aside this positive and primordial notion, with all its bearings on the life of human societies. Everywhere I see the inevitable expression of the Infinite in the world. By it the supernatural is seen in the depths of every heart. The idea of God is a form of the idea of the Infinite. As long as the mystery of the Infinite weighs on the human mind, temples will be raised to the worship of the Infinite, whether the God be called Brahma, Allah, or Jehovah; and on the floor of those temples you will see kneeling men absorbed in the idea of the Infinite. Metaphysics do but translate within us the paramount notion of the Infinite. The faculty which in the presence of beauty leads us to conceive of a superior beauty—is not that, too, the conception of a never realized ideal? What are science and the passion for comprehending anything else, then, but the effect of the stimulus exercised upon our mind by the mystery of the universe? Where is the real fountain of man's liberty, where the true source of woman's dignity, but in the conception of the Infinite, in presence of which all men are equal?"

THE FUTURE OF KNOWLEDGE.

M. Pasteur has chosen the occasion of his reception in the Academy to speculation largely upon what is in the nature of the case undemonstrable. But the truth is that the career of a great scientific discoverer suggests speculations as little demonstrable, perhaps, but of a different kind from these. Ever since thought began, mankind has wondered as to its own nature and its own destiny. It will go on wondering to the end of time, whatever new facts science may bring to light, whatever new worlds beyond the Milky Way or within the compass of a speck of dust may be revealed by telescope or microscope. It may be allowed, however, in the presence of a personality like that of M. Pasteur, or of the still greater discoverer whose loss the world is mourning, to look forward upon the future of knowledge, to ask how far all these new acquisitions will in the future modify our life, our practice, our methods of study. M. Renan, to whom a curious fortune gave the task of receiving M. Pasteur, has, in an interesting passage of his own autobiography given it as his belief, that a century hence mankind will study very little else than physical science. The time, he thinks, will come when the historical sciences will be thrust into the background; all that they have to teach will be known, and men will feel comparatively little interest in their own past. On the other hand, the more they know of nature, the more there will be to be known. Chemistry and physiology offer inexhaustible fields for research; and the truths which they reveal will prove more and more interesting to mankind. It is very difficult to say what men will think or do a hundred years hence; but it seems likely enough that this will be the tendency of study. Certainly, even now, the men of science are becoming more and more important factors in the life of all of us. They are little by little winning the fight against disease; they are giving us facts, and enabling us to found our beliefs on the sure ground of knowledge. Their influence must surely become greater and greater as time goes on; for humanity always reserves its highest honors for those who teach it to know.—*London Times*

AIR-REFRIGERATING MACHINERY.

At a recent meeting in London of the Institute of Civil Engineers, a paper was read "On Air-Refrigerating Machinery and its Applications," by Mr. J. J. Coleman.

The paper first dealt with the thermodynamic laws regulating mechanical refrigeration as successively enunciated by Joule, Sir William Thomson, Rankine, Clerk-Maxwell, and others, particularly pointing out the fact that atmospheric air having lately been proved to be the vapor of a liquid, there was no essential difference in the theory of machines for producing cold, whether air or the vapors of such substances as ether and ammonia were employed. Any machine which was worked through the medium of a readily-condensable vapor had its action limited by the boiling point of the volatile liquid, and therefore it was impossible with such machines to get so large a range of cooling in one operation as could be accomplished by air. The low temperatures which Pictet required for the liquefaction of oxygen and hydrogen were obtained in stages, first by ebullition of liquid sulphurous anhydride *in vacuo*, producing sufficient cold to liquefy carbonic acid gas at a pressure of four atmospheres, and then in taking advantage of the still greater cold produced by the ebullition of the liquid carbonic acid gas *in vacuo*. There was, however, no reason to suppose that the same or much lower temperatures could not be obtained by the compression and expansion of air in a single operation.

The boiling point of ether in the air was 95 deg. Fahr., so that to use it as a medium for refrigeration it must be evaporated *in vacuo*—that was, a pump was required which caused it to boil rapidly, and it became cooled as the vacuum increased; but the cooler it became the more slowly it evaporated, until when its temperature sank to a little below zero, evaporation ceased, although the pump might be maintaining the vacuum. It followed that if the brine, which was usually the medium being cooled, returned back to the boiling ether without having picked up heat from the substance being cooled, the action was gradually diminishing. This phenomenon was very likely to occur when the brine cooled by such a machine circulated in pipes through a chamber containing atmospheric air, more or less saturated with aqueous vapor, and as would be the case with a chamber containing fresh meat being cooled. The brine pipes in such circumstances became externally coated with a non-conducting covering of ice, which, unless removed, accumulated to the extent of several inches in thickness, thus interfering with the transfer of heat, and preventing the room from being reduced to a lower temperature than the freezing point of water, or the melting point of the exterior surface of the crust which surrounded the pipes, while the brine was liable to be returned to the evaporating ether at lower temperatures than it should for the economical working of the machine. The same remarks applied to the employment of sulphurous anhydride and of ammonia, the limiting action in the case of ammonia, which was considered the most effective in practice, being about 35 deg. below zero Fahrenheit when it was employed at atmospheric tension, as in Carré's process, or in Reece's process, though of course much lower when evaporating into a vacuum, as in Professor Lindé's machine.

Almost all the statements as to the performances of these machines referred to their employment under favorable conditions, namely, the cooling of water or other fluids, or the making of ice, in which the temperature of the saline solution or glycerine transferring the heat never need sink below 20 deg. Fahr. When they came to be employed for cooling solids, such as masses of meat, to temperatures below freezing point, great practical difficulties occurred in the transfer of the heat through the non-conducting air in which the meat was suspended to the pipes containing the brine, unless such pipes or other equivalent circulating apparatus were brought into close proximity to the solid masses. On board ship such arrangements were almost impossible if the ship's hold had to be employed for general cargo on the outward voyage, and in any case networks of such circulating apparatus were inconvenient and liable to leakage and injury of the cargo.

From these considerations, even if the use of dangerous chemicals on board steamers were allowable, it was apparent that cold-air machines, in which air was first compressed and then expanded, were the most convenient form of refrigerating apparatus; and it was also clear that they were the most convenient form of machine for cooling the air of apartments generally.

The great enemy of cold-air machines was friction encountered in the working of the machinery, particularly that which resulted in the development of heat in the expansion cylinder. In regard to the prime cost of machinery, experience had proved that not much difference existed for a given amount of cooling power whichever system of refrigeration was adopted,

The general principles upon which cold-air machines should be constructed, as regarded the arrangement of cylinders, had been laid down by Rankine and Sir W. Thomson in 1852, the former at the same time proposing a form of thermodynamic machine for the reverse process of heating buildings, and various practical attempts to make cold-air machines successful, and which were minutely described by the author, were made between that year and the year 1877, none of them being thoroughly successful, excepting the machines of Mr. Kirk, introduced in 1862, and which was not a machine for circulating cold air, but for producing ice or cooling liquids by the alternate compression and expansion of a confined volume of air. These attempts were failures, chiefly because of disregard or ignorance of the peculiar behavior of aqueous vapor which formed a constituent part of the atmosphere.

An attentive consideration of the matter upon general principles had led to the following conclusions:

1. That atmospheric air was really not air alone, but a mixture of aqueous vapor and air, and that when such mixture was compressed into pipes surrounded externally by water of the same temperature as the air before compression, the invisible vapor of the air became condensed in the direct ratio of the compression, in virtue of the law of physics demonstrated by Dalton, and expressed by the statement that a cubic foot of air in contact with water contained exactly the same weight of vapor, whatever might be the density of the air. If the density was increased, the vapor liquefied—if it was diminished, water evaporated into the air.

2. Therefore compressed atmospheric air of usual humidity was not made wetter by injection of water, provided the surplus water was run off continuously by automatic traps, air being actually dried by compressing it in contact with water, removing the water, and expanding it.

3. Direct injection was the quickest and most effective method of cooling air to the temperature of the water, which was a condition necessary to the working of a machine with the least expenditure of power.

4. Injection of a shower of water into freshly compressed air tended to settle the fog caused by the sudden condensation of the invisible atmospheric vapor, thus facilitating its removal by traps.

5. That while the direct injection of water was desirable for cooling the air to the temperature of the water, it was not absolutely essential, if the compressed air was passed through a sufficient number of pipes surrounded by cooling water, the ultimate result being that the compressed air could only be reduced to the temperature of the water, which was not sufficient to liquefy the vapor usually contained in the air, except the air pressures employed were excessively high, which was fatal for working a machine economically.

6. That every pound of vapor unnecessarily condensed liberated as much heat as would raise about four thousand times its weight of air 1 deg. Fahr., and that air absolutely dry was a condition that would abstract the fluids of animal tissue, and indeed was a phenomenon unknown in nature, the degree of humidity being generally over 50 deg., even in what was, in common parlance, called "dry air."

7. That a convenient way of liquefying such vapor was to apply a portion of the cold air produced by the machine to the external surface of the pipes conveying the compressed air already cooled by water to the cylinder in which it was to be expanded, the liquid being removed by automatic traps.

The last principle had not been applied in practice in this country prior to the author adopting it in conjunction with Messrs. Bell.

The author commenced to design machines in 1877 which afforded a uniform degree of dryness in the cold air, suitable for carrying provisions without drying up their juices, and used principally for the importation of meat from the United States. The experimental machine which brought the first cargo from New York, in 1879, and the first cargo of meat from Australia, in 1880, was described in detail, as also the construction of the machines generally employed in Transatlantic traffic, which had a pair of compressors of 16 in. diameter, steam cylinder of 18 in. diameter, an expansion cylinder of 17 in. diameter, and 2 feet length of stroke. These machines had been worked continually from leaving New York to the arrival in British waters, and had brought over, to the end of 1881, meat to the value of between £2,000,000 and £3 000,000 sterling. Several machines constructed for land purposes and erected at Sydney, Barrow-in-Furness, Waterford, Limerick, Hamburg, etc., were described with the cooling chambers attached; also machines erected in the West Indies, on the Cunard liner Servia, and on the Spanish mail steamer Antonio Lopez. A list of the machines at work in the Australian traffic was given, which included those on the Cuzco, Dunedin, Chimborazo, Lusitania, Kaiser-i-Hind, Rome, and Carthage, erected by the Bell-Coleman Company; and those on the Protos, Europa, Clyde, Orient, Garonne, and Sorrento, erected by other makers, the sizes of the cylinders and comparative powers being described, and which had brought into the United Kingdom frozen meat to the value of about £50,000 sterling.

The latter part of the paper dealt with the efficiencies of cold-air machines and formulæ for their calculation; and stated that air-refrigerating machines of the larger sizes were giving an efficiency not much different from that of ether and ammonia machines; and it also pointed out the probable future development in ventilating and cooling buildings, especially in India and other tropical countries, which, by calculation, should not cost more than one-tenth of a penny per head per hour.

SEA-GOING TONNAGE OF THE WORLD.

The recently published annual report of the Canadian Minister of Marine, for 1881, gives the following statement of the sea-going tonnage of the world of vessels of over 100 tons register, except in the case of Canada, which includes all classes of vessels on its register books. In the case of Canada it is impossible to get at the number and tonnage of vessels of over 100 tons, as the department makes no discrimination in their annual reports, a circumstance which gives Canada a much higher place in the table than it rightly deserves.

In summing up the totals the Canadian tonnage is not counted, as it is already included with the British tonnage.

Nationality.	Steamers.	Net Tonnage of Steamers.	Sailing Vessels.	Net Tonnage of Sailing Vessels.	Total Net Tonnage.
British (including Canada and colonies)......	4,106	3,133,453	18,403	5,435 851	8,569,304
American	569	408,496	6,045	2,055,087	2,463,583
Norwegian. ...	44	53,340	4,178	1,396,289	1,449,629
Canadian	954	119,158	6,440	1,191,738	1,310,896
German.........	304	234,660	3,011	945,696	1,180,356
Italian.........	108	75,646	3,018	930,576	1,006,322
French.........	361	302,432	2,678	514,101	816,533
Russian.........	179	87,997	2,113	470,342	558,339
Swedish.........	249	66,204	1,985	404,958	471,162
Spanish.........	237	144,691	1,568	322,441	467,132
Dutch	112	81,048	1,149	342,545	423,593
Greek	18	11,019	1,770	341,770	352,789
Austrian	86	66,352	597	229,435	295,787
Danish	115	51,159	1,165	178,799	229,988
Portuguese......	19	12,518	434	90,841	112,354
South American.	89	40,822	262	89,387	130,209
Other countries	261	110,693	661	154,797	265,493
Totals	6,857	4 880,558	49,037	13,911,915	18,792,472

Vessels included under the nationality of British, etc., average in size a little over 380½ tons, American vessels nearly 372½ tons, Norwegian something over 343 tons, Canada

only a little over 177 tons. Germany's average is a little over 356 tons, Italy's something over 321½ tons, while, taking the tonnage of the world, each vessel will average a little over 336 tons.

The "other countries" of the table comprise those which have a total net tonnage less than 100,000 tons each. To complete the record these excluded nationalities are given as below: Turkish, 10 steamers, with a net tonnage of 5,579 tons; 390 sailing vessels, net tonnage 63,729 tons—total net tonnage, 69,308 tons. Belgian, 163 steamers, 53,811 tons; 30 sailing vessels, 12,121 tons—total net tonnage, 65,932 tons. Central American, 14 steamers, 3,760 tons; 157 sailing vessels, 50,243 tons—total net tonnage, 54,003 tons. Asiatic, 35 steamers, 24,823 tons; 57 sailing vessels, 22,881 tons—total net tonnage, 47,704 tons. Egyptian, 33 steamers, 16,887 tons; no return of sailing craft. Roumanian, 1 steamer, 111 tons; 19 sailing vessels, 3,184 tons—total tonnage, 3,295 tons. Liberian, 3 sailing vessels, 999 tons; no return of steamers. Tunisian, 1 steamer, 726 tons; 2 sailing vessels, 188 tons—total tonnage, 914 tons. Zanzibar, 1 steamer, 720 tons, and Jerusalem, 1 sailing vessel, 293 tons.

ECONOMY OF THE WINDMILL AS A PRIME MOVER.*

By Alfred R. Wolff, M.E.

In the course of professional work I have repeatedly had occasion to investigate the question of the impulse of wind upon windmills, and to observe the economical performance of the latter. From time to time I have published various results of these investigations, but have not given a record of the actual economy of the windmill, the subject proper of this note Before, however, setting forth the special economy in the use of the windmill as a prime mover for small powers, it is well to refer briefly to some publications which may be of interest in connection with the general subject.

For the early history of windmills and a description of European windmills, Fairbairn's "Mills and Millwork" may be consulted to advantage. For a description of the details of American windmills, see article on Windmills in Appleton's Cyclopedia of Mechanics, 1880. For an account of experiments on windmills, see Smeaton's "Miscellaneous Papers," and Coulomb's "Théorie des Machines Simples." For the best angles of impulse and "weather" for windmill blades, see *Engineering and Mining Journal*, October 7, 1876, and Appendix I. of this note. The question of the impulse of wind upon windmill blades involves too the consideration of the relation between the velocity and pressure of the wind. A concise summary of this question, useful to no small extent in its reference to the journals containing the original publications of those who have given the subject attention, will be found in a paper by Mr. F. Collingwood, C.E., read before the American Society of Civil Engineers, April 6, 1881, on "An Examination into the Method of Determining Wind Pressures." In Appendix II. of this note will be found the tabulated result of the writer's own work in this connection, in which the effect of temperature has received its due consideration. In the *Journal of the Scottish Meteorological Society*, 1880, Mr. F. Stevenson describes some interesting experiments, tending to show the effect of the height of observation above the ground on the relative velocity and pressure of wind. (See also *Engineering*, Jan. 14, 1881.)

Having thus indicated some of the publications where can be studied those considerations which affect the construction of windmills, and which to some extent determine as well its efficiency, I propose now to direct attention to the demonstration of the fact that whatever improvement in efficiency be possible in the future, windmills, as at present constructed, are the most economical prime movers for those uses for which they are specifically designed.

In this demonstration, conclusions will be based only on observed facts, or actual running results. I am enabled to do this, inasmuch as some five years ago, one of the most prominent windmill manufacturers came to me with a few scattered data of actual performances of his mills, which, however, were sufficient by means of deductions and analogy from theoretical principles, to warrant the preparation of the following

TABLE.

Designation of Mill.	Velocity of Wind in Miles Per Hour	Revolutions of Wheel.	Gallons of Water Raised Per Minute to an Elevation of.						Equivalent actual useful horse power developed	Average number of hours per day during which this result will be obtained.
			25 feet	50 feet	75 feet	100 feet	150 feet	200 feet		
8½ ft. wheel..	15 to 20	70 to 75	6.162	3.016	....	....	....	....	.04	8 to 10
10 ft. wheel..	15 to 20	60 to 65	19.179	9.563	6.638	4.750	....	....	.12	8 to 10
12 ft. wheel..	15 to 20	55 to 60	33.941	17.952	11.851	8.485	5.680	....	.21	8 to 10
14 ft. wheel..	15 to 20	50 to 55	45.139	22.569	15.354	11.246	7.807	4.998	.28	8 to 10
16 ft. wheel..	15 to 20	45 to 50	64.600	31.654	19.542	16.150	9.771	8.075	.41	8 to 10
18 ft. wheel..	15 to 20	40 to 45	97.682	52.165	32.513	24.421	17.485	12.211	.61	8 to 10
20 ft. wheel..	15 to 20	35 to 40	124.950	63.750	40.800	31.248	19.284	15.938	.78	8 to 10
25 ft. wheel..	15 to 20	30 to 35	212.381	106.964	71.604	49.725	37.349	26.741	1.34	8 to 10

Since the preparation of this table over a thousand windmills have been sold on its guarantee, and in all cases the actual results obtained, both in this country and elsewhere, did not vary sufficiently from those above presented to cause any complaint whatever; a proof that the results as tabulated are very close or certainly not too high. If it be claimed that the horse power developed appears small from the standpoint of a (false) prevalent popular opinion, it should be observed in response that the actual results noted in the table are in close agreement with those obtained by theoretical analysis of the impulse of wind upon windmill blades. The manufacturer's own observations during the past five years have led him to conclude that they are correct. It will therefore be just to base the economy of the windmill as prime mover on the performances recorded in this table, and the expense of obtaining the power will be presented further on.

Conceding for a moment its economy, the possible employment of the windmill as prime mover is dependent as well on other considerations. The objection urged against the use of windmills is the uncertainty of the motive fluid—wind; but we will see that this objection serves not to prevent but only to restrict the use of the windmill as prime mover. Of course it must be acknowledged that there are minutes and hours of total calm, and this restricts the employment of the windmill for such purposes, where either the nature of the work done by the windmill allows of its being suspended during a calm, as work on a farm, for instance, or where the work can be stored as in pumping water for a variety of purposes, or in compressing air, or, as was lately proposed by Sir William Thomson,† for storing electricity by means of dynamo machines and electrical accumulators. There is another restriction which goes into practical effect, namely, that the large size of a windmill for a given power makes it practically desirable only to be used for small powers. But actually it is only designed for the use of small powers, usually between $\frac{1}{25}$ and 4-horse power,* and for such powers it will be shown in this note that it is the most economical and serviceable prime mover for the purposes for which it is designed.

The difficulty urged by Sir William Thomson to its adoption, in its present state of development, for storing electrical accumulators, is the *first cost* of the windmill, but this was doubtless an oversight,† for the *interest* on the capital expended and not capital itself becomes one of the items of current expense in judging of the economy of prime movers, and, as will become evident from the contents of this note, the question of expense of producing power will not prove an objection, but, on the contrary, the best reason for the introduction of windmills to charge electrical accumulators.

It must be specially mentioned that experience has shown that the wind blows fast enough to run the windmill up to the regulating speed in the above table on an average of eight to ten hours per day of twenty-four hours, and our estimate of work done and expense of power will be based on an actual running of only eight hours per day.

The current expense of any prime mover, or the cost of obtaining the horse power developed per unit of time, which alone should form the basis of a comparison of the economy of different prime movers, consists principally of interest, repairs, and depreciation of plant, cost of fuel, oil, and attendance. In windmills the cost of fuel is zero, wind being a free gift of nature. The attendance required for the self-regulating windmills, designated in the above table, amounts only to filling the oil cups three or four times a month, the work of a few minutes, which any one can attend to. If any account is to be taken of this service, an allowance of fifteen cents a month would really be quite extravagant. In the following table such allowance has been made. Experience has shown that the repairs and depreciation items, jointly, are amply covered by 5 per cent. of the first cost per annum. Interest is calculated at 5 per cent. per annum. The oil used is a very small quantity—a few gallons per year—and is allowed for in the table according to the size of mill. All the items of expense, including both the interest and repairs, are reduced to the hour by dividing the costs per annum by 365×8=2,920, the interest, etc., for the twenty-four hours being charged on the eight hours of actual work. By multiplying the figures in column 5 by $\frac{365 \times 8}{100 \times 0{\cdot}05} = 584$, the first cost of the windmill in dollars is obtained:

TABLE.—Showing Economy of the Windmill.

1	2	3	4	5	6	7	8	9	10
Designation of Mill.	Gallons of Water Raised 25-Foot per Hour.	Average Number of Hours per Day during which this quantity will be Raised.	Equivalent Actual Useful Horse-Power Developed.	Expense of Actual Useful Power Developed in Cents per Hour.					Expense per Horse Power in Cents per Hour.
				For Interest on First Cost. (First Cost, including cost of Windmill, Pump and Tower. 5% per Annum.)	For Repairs and Depreciation, 5 per cent of First Cost per Annum.)	For Attendance.	For Oil.	Total	
8½ ft. wheel	370	8	.04	0.25	0.25	0.06	0.04	0.60	15.0
10 ft. wheel.	1,151	8	.12	0.30	0.30	0.06	0.04	0.70	5.8
12 ft. wheel.	2,036	8	.21	0.36	0.36	0.06	0.04	0.83	3.9
14 ft. wheel.	2,708	8	.28	0.75	0.73	0.06	0.07	1.63	5.8
16 ft. wheel.	3,876	8	.41	1.15	1.15	0.06	0.07	2.43	5.9
18 ft. wheel.	5,861	8	.61	1.36	1.36	0.06	0.07	2.83	4.6
20 ft. wheel.	7,497	8	.78	1.70	1.70	0.06	0.10	3.56	4.5
25 ft. wheel.	12,743	8	1.34	2.05	2.05	0.06	0.10	4.26	3.2

The number of gallons pumped by the 30 foot and 35 foot mills and larger sizes, and the economy of the same, are not given in the above table, for the number of larger mills in operation is not sufficient to insure the authenticity of the results thus far obtained. The performance of the 30-foot mill, as far as observed, seems to gravitate to a pumping capacity equivalent to 2·4 horse power, and an expense of 2·5 cents per horse power per hour.

When the figures in the table are contrasted with the cost of pumping the same amount of water by other prime movers, where in addition to expense of interest, repairs, depreciation, and oil, there are the greater expenses of fuel and attendance, and often extra insurance on property owing to the use of steam, the economy of the windmill must be evident to all.

To recapitulate: The figures given in the body of this note are the results of actual experience with hundreds of windmills, and as such, it was believed, would not be without interest. They prove conclusively that at the present time the windmill is the most economical prime mover for the powers and purposes, outlined in this note, and for which they are usually designed.

APPENDIX I.

In a "Dissertation on the Theory and Practice of Windmills," published in the *Engineering and Mining Journal*, October 7, 1876, the writer developed the formula:

$$\text{ton}\ a = \frac{v}{c} + \sqrt{1 + \left(\frac{v}{c}\right)^2}$$

from which the best angle of impulse might be ascertained.

In this formula

a represents the angle of impulse of the wind upon the windmill blade (or sail), at any point of the blade, for maximum effect.

v=the velocity of the blade (at such point) in feet per second.

c=the velocity of the wind in feet per second.

The accompanying diagram is the graphical interpretation of that formula, the curves showing the best angles of impulse and "weather." The angle of "weather" is the complement of the angle of impulse, and is the angle which an element of the blade or sail makes with its plane of motion. Since there is no difference of effect between that caused by the blades moving against the air, and that caused by the air (or wind) striking upon the blades (assuming the same velocity in both cases), the angles given in the diagram will be found to be those of maximum efficiency for ventilating purposes as well as for windmills.

In the above diagram, the ordinates represent the best angles of weather and impulse expressed in degrees, and the abscissas the ratio of the velocity of the wind to the velocity of the windmill blades. Thus assuming the velocity of the wind to be 31·416 feet per second, the diameter of the wheel to be 35 feet, and the number of revolutions per minute to be made to equal 30, the velocity of the wind wheel at a point 2½ feet from the center of the shaft will be 7·854 feet per second; at 5 feet from the center 15·708; at 7½ feet, 23·562, etc., and the ratio of the velocity of the wind to the velocity of the sail $\frac{v}{c}$ will at 2½ feet from center of shaft equal 0·25; at 5 feet, 0·50; at 7½ feet, 0 75, etc. The best angle of weather equals therefore at a distance 2½ feet from the center of the shaft, 38°; at 5 feet from the center 32°; at 7½ feet, 27°, etc.; and the best angle of impulse equals at a distance of 2½ feet from the center of the shaft, 52°; at 5 feet from the center, 58°; at 7½ feet, 63°, etc.

APPENDIX II.

TABLE.—Showing Relation between Velocity and Pressure of Wind.

Velocity of Wind.		Pressure of Wind in Pounds per Square Foot of Plane Surface, Perpendicular to its course, when P=2116.5; and Temperature of Wind=					
Miles per Hour.	Feet per Second.	0° F.	20° F.	40° F.	60° F.	80° F.	100° F.
1	1.46⅔	.005371	.005147	.004940	.004750	.004574	.004416
2	2.93⅓	.021482	.020586	.019761	.019001	.018294	.017644
3	4.39⅓	.048336	.046318	.044465	.042751	.041166	.039694
4	5.86⅔	.085933	.082345	.079048	.076008	.073188	.070568
5	7.33⅓	.134271	.128668	.123514	.118780	.114336	.110267
6	8.80	.193354	.185287	.177867	.171017	.164675	.158784
7	10.26⅔	.263186	.252205	.242112	.232780	.224148	.216140
8	11.73⅓	.343767	.329423	.316228	.304050	.292774	.282265
9	13.20	.435283	.416945	.400243	.384828	.370555	.357305
10	14.66⅔	.537188	.514772	.494151	.475121	.457488	.441196
11	16.13⅓	.650036	.622908	.597955	.574933	.553600	.533815
12	17.60	.773645	.741357	.711666	.684244	.658886	.635301
13	19.06⅔	.908030	.870122	.835260	.803085	.773,286	.745682
14	20.53⅓	1.053166	1.010206	.968770	.931449	.8968.79	.864814
15	22.00	1.209087	1.158616	1.112190	1.069347	1.029670	.992841
16	23.46⅔	1.375790	1.318364	1.265523	1,216763	1.171621	1,129707
17	24.93⅓	1.553273	1.488425	1.428786	1.373721	1.322751	1.275429
18	26.40	1.741556	1.668839	1.601961	1.540180	1.483086	1,429470
19	27.86⅔	1.940634	1.859596	1.785056	1.716260	1.652571	1.593429
20	29.33⅓	2.150516	2,060705	1.978086	1.901653	1.831270	1.765740
25	36.66⅔	3.362260	3.221749	3.092521	2.973361	2,862857	2.760359
30	44.00	4.845284	4.642062	4.456311	4.284344	4.125157	3.972371
35	51.33⅓	6.600829	6,324565	6.070498	5.836055	5.619046	5.417590
40	58.66⅔	8.630851	8.268791	7.936307	7.627966	7.345881	7.082012
45	66.00	10.935522	10.476877	10.055158	9.666070	9.308075	8,971746
50	73.33⅓	13.518265	12.950566	12.429968	11.947176	11.501614	11.089085
60	88.00	19.525904	18.702903	17.947148	17.250017	16.606025	16.006591
80	117.33⅓	34.981530	33.497300	32.133920	30.877160	29.715020	28.663716

In obtaining the above data, attention was paid to the facts that the pressure depends upon both the velocity and the density of the air, and that this density depends upon the temperature, the barometric pressure, and the pressure due to the motion of the air. This table is for the average height of the barometer (P=2,116 5 lb. per sq. ft.), and for any other barometric pressure the figures in the table must simply be multiplied by the ratio of the said barometric pressure reduced to its value for temperature of air of 32° F to 2,116·5. Thus letting p_1 = barometric pressure at any absolute temperature t, then $p = \frac{p_1 \times t}{491\ 4}$, and the figures in the table corresponding to wind pressure must be multiplied by $\frac{p}{2{,}116{\cdot}5}$.

THE NAVAL AND SUBMARINE EXHIBITION, LONDON.

The multifarious collection of mechanical and engineering appliances adapted for all kinds of uses upon and under the sea, which has been on view lately at the Agricultural Hall, Islington, could not fail to be interesting, and the measure of its popularity may be judged from the fact that the daily average of visitors was something over 7,000. It would be utterly futile to attempt any detailed description of the entire Exhibition within the space at our disposal, but we may say that we were chiefly struck by the utter absence of anything like order or arrangement, the various classes of exhibits being for the most part intermixed in such a fashion that made it an extremely difficult task to find any particular object, the elaborate catalogue being of little assistance, as it merely followed the consecutive numbering of the spaces, so that if one wanted to find a particular thing he must first turn to the index of exhibits, where he would find references to from two or three to twenty or thirty different pages in the body of the catalogue. It is obvious that a more simple and satisfactory plan would have been to allot a special section of the building to each class of exhibit, and to arrange the catalogue so that all reference to specimens of similar kind should appear in consecutive order instead of being scattered about through a volume of nearly two hundred pages. Turning to our illustrations, we have first one of the many forms of fog-horns, the deafening sounds of which assailed the ears of the visitors at frequent intervals; next, Messrs. Foster & Fleuss' patent submarine and mining lamp, which, being charged with condensed oxygen gas, a methylated spirit burner and cotton wick, in combination with a piece of lime, gives an intense light, which will burn from four to six hours in complete independence of the surrounding atmosphere. It has already been practically tested both under water and in vitiated mines, where, in conjunction with the Fleuss knapsack diving apparatus, which obviates the necessity of the air pump, it has been the means of saving several lives. No. 2 is a model of the celebrated yacht Formosa, made and exhibited by H. J. Pope, of the Coastguard Station, Hastings. No. 4 a contrivance invented by Mr. R. G. Sayers for preventing the sinking of ships after they have sprung a leak or been in collision, by attaching bags or balloons to the sides, and afterwards inflating them with air by means of the ship's pumps, an operation which can be effected in the short space of eighteen minutes. No. 5 is a miniature balloon or parakite, with electric lamp and set of rockets or magnesium lights attached, designed to be sent up from a ship in distress, the contrivance being held captive by an insulated wire run off a windlass on deck, and the electricity being supplied by the ship's engines in case of steam vessels, and in sailing vessels by a suitable battery. This is the invention of Mr. Arthur Shippey, of King Street, Cheapside, who is also perfecting a plan for placing specially adapted electric lamps on all the buoys around our coasts, connecting them by wires with batteries in the adjacent lighthouses. The Greek lamp, with the sponge, was found at a depth of 140 feet by a Greek sponge fisher, and is believed to be very ancient, It is exhibited by Messrs. Siebe, Gorman & Co., submarine and mining engineers, who also show some relics of the Royal George and the Eurydice; as well as their own diving apparatus and other contrivances. The large diving tank, in the center of the hall, was a very great attraction, although little could be seen

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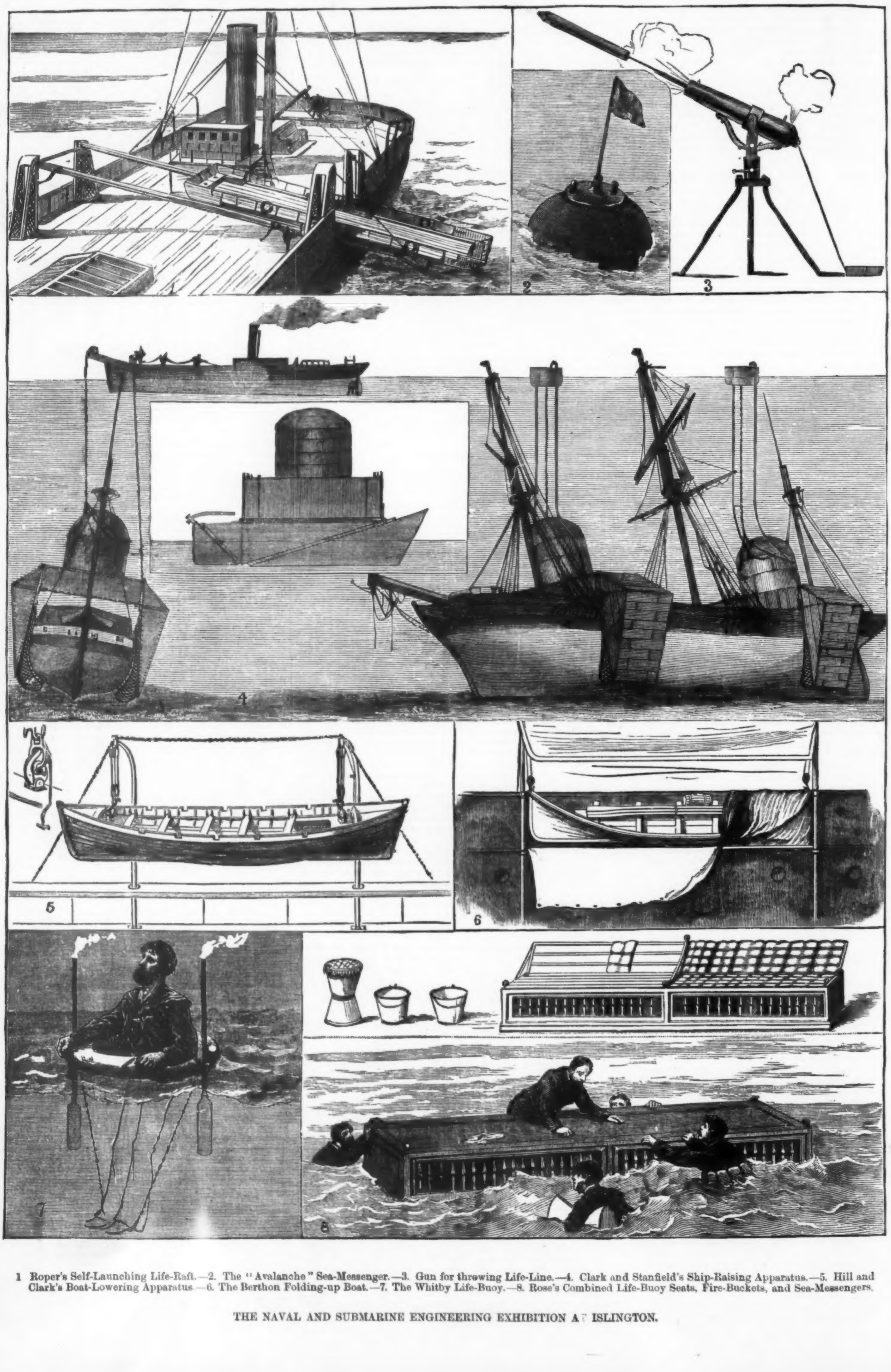
* A paper read before the American Society of Mechanical Engineers, April 21, 1882.

† Presidential address "On the Sources of Energy in Nature Available to Man for the Production of Mechanical Effect," delivered before Section A of the British Association for the Advancement of Science, 1881.

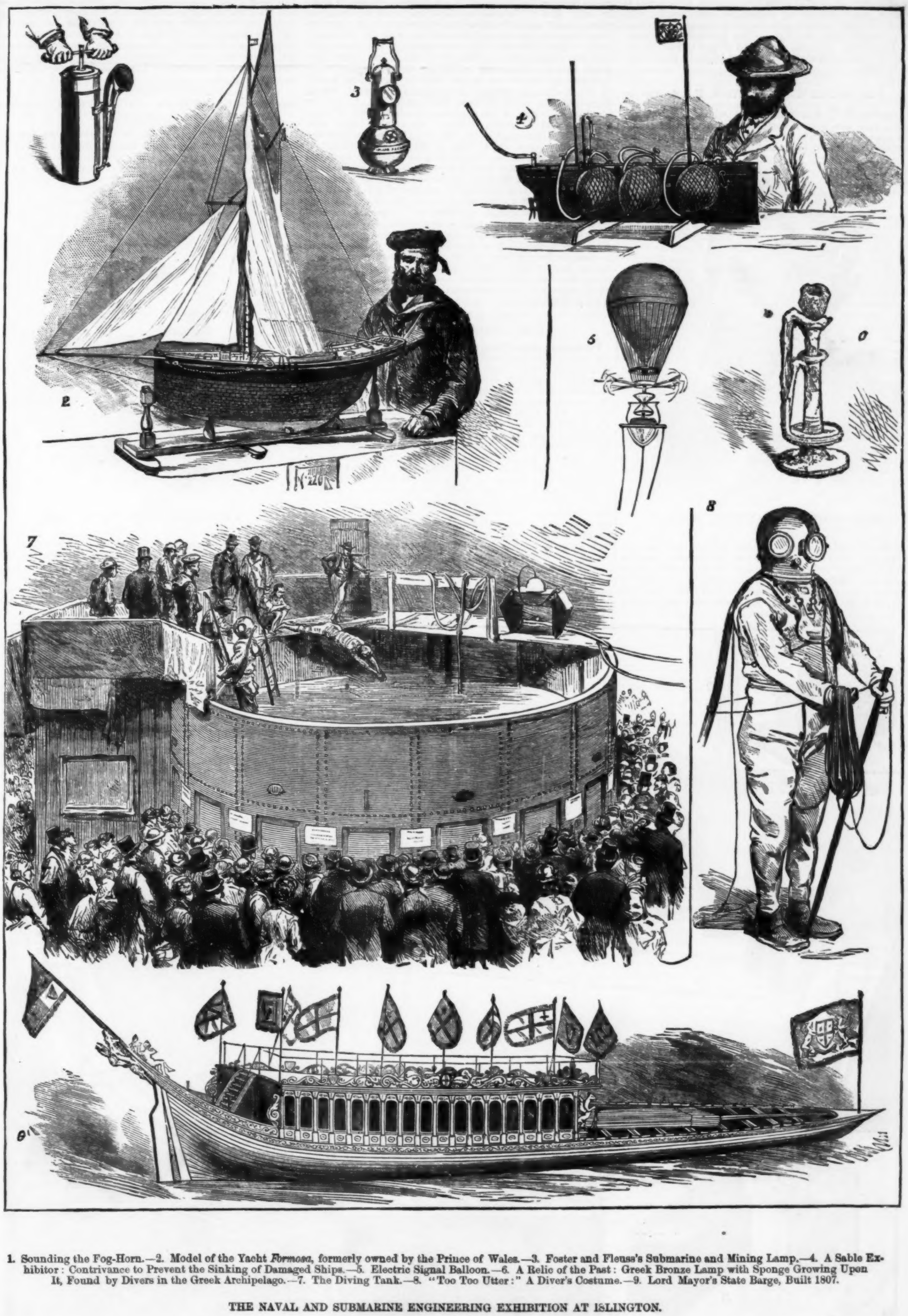
* Coulomb, in his experiments with a windmill of four sails, 70 feet in diameter breadth of sails 6 5-8 feet, the wind blowing at a velocity of fifteen miles per hour, obtained an actual useful result equivalent to about seven horse power.

† In the same paper Sir William Thomson, in estimating the cost of utilizing the power of the Niagara Falls for electric lighting, correctly considers the interest on first cost in determining the economical aspect of the question. The oversight noted in the text becomes important and worthy of mention only, inasmuch as any statement of so distinguished and justly esteemed an authority as Sir William Thomson is apt to be accepted on the basis of authority alone—and it must be added that the great caution usually displayed by the most eminent living English physicist entitles him *prima facie* to this mark of consideration.



1 Roper's Self-Launching Life-Raft.—2. The "Avalanche" Sea-Messenger.—3. Gun for throwing Life-Line.—4. Clark and Stanfield's Ship-Raising Apparatus.—5. Hill and Clark's Boat-Lowering Apparatus.—6. The Berthon Folding-up Boat.—7. The Whitby Life-Buoy.—8. Rose's Combined Life-Buoy Seats, Fire-Buckets, and Sea-Messengers.

THE NAVAL AND SUBMARINE ENGINEERING EXHIBITION AT ISLINGTON.



1. Sounding the Fog-Horn.—2. Model of the Yacht *Formosa*, formerly owned by the Prince of Wales.—3. Foster and Fleuss's Submarine and Mining Lamp.—4. A Sable Exhibitor: Contrivance to Prevent the Sinking of Damaged Ships.—5. Electric Signal Balloon.—6. A Relic of the Past: Greek Bronze Lamp with Sponge Growing Upon It, Found by Divers in the Greek Archipelago.—7. The Diving Tank.—8. "Too Too Utter:" A Diver's Costume.—9. Lord Mayor's State Barge, Built 1807.

THE NAVAL AND SUBMARINE ENGINEERING EXHIBITION AT ISLINGTON.

through the side windows after one had struggled to obtain a position in front of them. From the small platform above, however, as well as from the galleries, a view was to be had of many interesting submarine experiments, with different kinds of diving apparatus, contrivances for raising sunken vessels, and the like. The remaining sketches, "Too Too Utter," and the last Lord Mayor's State Barge, need no further explanation than that given in their titles. —*The Graphic.*

PROFESSOR W. E. AYRTON, F.R.S.

PROFESSOR W. E. AYRTON, F.R.S.

Professor W. E. Ayrton, F.R.S., who, with Professor John Perry, is the joint inventor of the electrical railway, of which an illustration is given, was educated at University College School, where he gained numerous prizes, and entering subsequently into the college gained the Andrews Exhibition in 1865 and the Andrews Scholarship in 1866. Passing his examination for his first B.A. in 1867, he in the same year came out first in the Entrance Exhibition for the Indian Government Telegraph Service. He then was sent by the Secretary of State to study electrical engineering with Professor Sir William Thomson, coming out first at the Advanced Exhibition for the Indian Government Telegraph Service, and winning the scholarship. When in India he acted first as the assistant electrical superintendent, and subsequently as the electrical superintendent in the government telegraph department, introducing with Mr. Schwendler throughout British India a complete system of immediately determining the position of a fault in the longest telegraph line by electrically testing at one end. In 1872-3 Professor Ayrton was on special duty in England on behalf of the Indian Government Telegraph Department, and in charge of the Great Western Telegraph Manufactory in London on behalf of the engineers, Professors Sir William Thomson and Fleeming Jenkin. From the latter year until 1879 Professor Ayrton was the Professor of Natural Philosophy and of Telegraphy at the Imperial College of Engineering, Japan, the largest English-speaking technical university in existence. In 1879 he was appointed Professor of Applied Physics at the City and Guilds of London Technical College, Finsbury, and last year was elected a Fellow of the Royal Society. Since his appointment the City and Guilds of London Institute have established at Finsbury a school of electrical engineering, which is attended by some hundreds of pupils from fifteen to seventy years of age, and differs from anything of the kind previously established, in that for every hour of lecture, pure and simple, each student has the right to work himself for two hours making actual electrical measurements in the laboratory. The teaching throughout is far more practical and technical than anything hitherto attempted in electrical engineering.

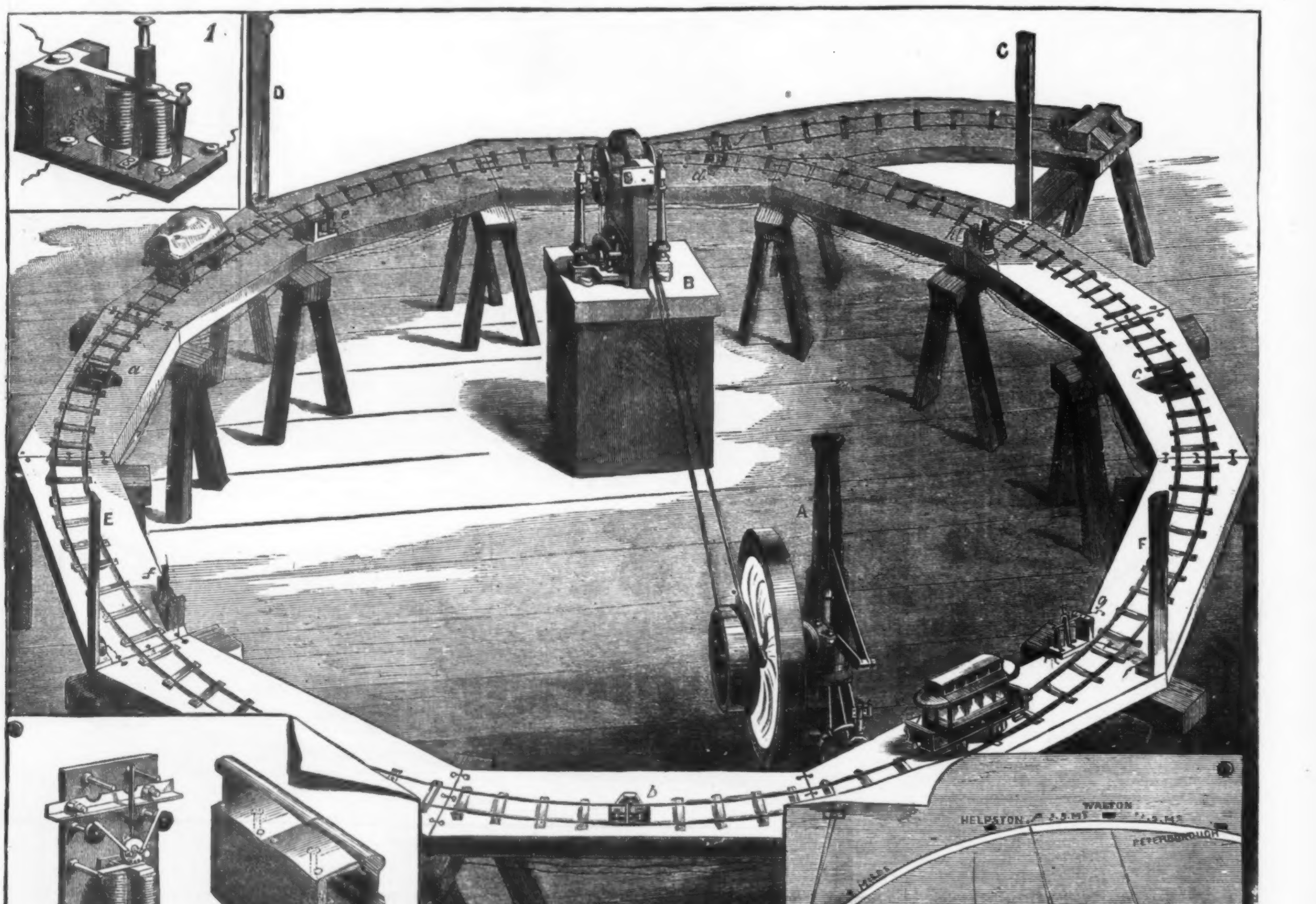
PROFESSOR JOHN PERRY.

Professor John Perry, M.E., learned both the theoretical and the practical rudiments of his profession in Belfast, by attending the classes of Professor James Thomson at Queen's College, and serving his apprenticeship at the Lagan Foundry. In 1870 he graduated as Bachelor of Engineering, and in that degree obtained first honors and the Gold Medal. In the same year Professor Perry obtained a Whitworth Scholarship, and became lecturer in physics at Clifton College, Bristol, as well as second mathematical master. There he established a physical laboratory, the first of the kind in English public schools, as the workshop was the first English public school workshop. In 1874 he was the honorary assistant of Professor Sir William Thomson at the University of Glasgow, and was afterward appointed a secretary of the Mathematical and Physical Section of the British Association. In the following year he accepted the offer of the Joint Professorship of Engineering at the Imperial College of Engineering, Yeddo, Japan, and thus had charge of all the engineering classes for four years, the Japanese Government regularly consulting him with regard to engineering works, and frequently deputing him to go to various parts of the country to report on harbors, bridges, roads, and river embankments. In 1879, returning to England, Professor Perry organized the works of Messrs. Latimer Clark, Muirhead & Co., and became the examiner in engineering to the City and Guilds of London Institute. Professor Perry has published numerous scientific papers, and his work on steam (Macmillan's "Huxley's Physiology" Series) has become the authorized text-book for cadets in the American Navy. Professors Ayrton and Perry are also joint authors of some fifty six scientific papers published in the Proceedings and Transactions of the Royal Society, Physical Society, Society of Telegraph Engineers, and other societies.

PROFESSORS AYRTON AND PERRY'S ELECTRIC RAILWAY.

PROFESSOR JOHN PERRY, M.E.

From the earliest period of the discovery that electricity could be employed to produce motion, the minds of electricians have been busy with the problem of how best to utilize so tremendous a power. With the invention during the last few years, also, of the various improved dynamo-electric machines, by which enormous quantities of the electrical current can be generated and transmitted to a distance, renewed attempts have been made to apply electricity to the



A.—Gas Engine Supplying Motive Power. B.—Magneto-Electric Machine. C, D, E, F.—Electric Current Indicators. *a, b, c, d.*—Contact Makers at the ends of each Section. *e, f, g, h.*—Blocking Electro-Magnets attached to each Section. 1.—Blocking Electro-Magnet (Enlarged). 2.—Contact Maker, as in Model. 3.—Contact Maker as required for Actual Use. 4.—Map Indicator, Automatically Showing the Position of Trains on the Line.

PROFESSORS AYRTON AND PERRY'S NEW ELECTRIC RAILWAY.

working of machinery, and of railway trains in particular. In 1878 MM. Chrétien and Félix made some noteworthy and practical experiments in plowing a field by means of electricity, and in 1879 Dr. Siemens showed in the grounds of the Berlin Exhibition a small model electric railway, 900 yards long. At the present time he has another electric railway, a mile and a half in length, working in the suburbs of Berlin. In the former the current was conveyed to the train by an insulated rail, rubbed by a metallic brush attached to the train, and returned by the ordinary rails on which the wheels ran. This current passing through an electromotor on the carriage set it in rapid rotation, and so propelled the train. In the present Berlin Railway the current is conveyed by one of the ordinary rails on which the wheels run, passing through the wheels on one side of the train to the electromotor underneath the carriage, and returning by the wheels on the other side through the other rail to the generator of electricity at the terminus of the line.

But in both these systems there will be considerable leakage of electricity from rail to rail, especially in wet weather, and consequent loss of power.

This, however, may be overcome by using the method employed by Dr. Siemens in 1881 in the electric tramway constructed for the Paris Electrical Exhibition, where the current was conveyed by two thick overhead insulated wires, and connection maintained between these and the moving tramcar by two flexible wires attached to the car, and which dragged along two little jockeys running on the thick overhead insulated wires. This, however, while practicable for slow traveling tramcars, would be scarcely feasible for trains intended to spin along at the rate of sixty miles an hour, and so inventors once more set their wits to work, and Professors Ayrton and Perry, the well-known electricians, have now matured, and are exhibiting in action, a plan by which numerous difficulties hitherto encountered can be surmounted. The chief feature of their railway is that instead of supplying the electricity to one very long, not very well insulated rail, they lay by the side of their railway line a well insulated cable, which conveys the main current. The rail, which is rubbed by the moving train, and which supplies it with electric energy, they subdivide into a number of sections, each fairly well insulated from its neighbor and from the ground; and they arrange that at any moment only that section which is in the immediate neighborhood of the train is connected with the main cable; the connection being of course made automatically by the moving train. As then leakage to the earth of the strong propelling electric current can only take place from that section of the rail, which is in the immediate neighborhood of the train, the loss of power by leakage is very much less than in the case of a single imperfectly insulated rail such as has been hitherto employed, and which being of great length, with its correspondingly large number of points of support, would offer endless points of escape to the motive currents. In one of their arrangements the sections of the line are short, and the weight of the train makes the connection between the main cable and the rubbed rail by depressing "the contact maker" it is over at the time. In another the sections are longer, and as a train enters a section, the wheels pass over levers placed in a "contact maker," and "turn on" the current by making connection between the rails in that particular section and the main cable. Thus a powerful electrical current is at once supplied to the electromotor on the engine through the wheels, and the train is propelled. Arrived at the end of the section another contact maker is passed over, the current is shut off, and turned on to the section then being entered. In this manner the leakage of electricity is reduced to a minimum, while another great advantage of the system is that each train absolutely blocks the section behind that on which it is traveling. As each contact box is passed not only is the current turned on to the section which it is entering and cut off from that which it is leaving, but it also, by a simple arrangement, prevents any current at all being supplied to the section it has left behind. Thus if any train enters it the train is stopped, not only from lack of electrical current, but also by the action of a powerful brake on the engine, which comes into action directly the electrical current ceases. Thus all possible chance of collision is avoided. When, however, the first train has entered a new and a third section the current is automatically restored to the rails of the first section, and the second train at once proceeds on its journey. To make the system more clear we will suppose three sections, A, B, and C. A train arrives at B at the same time as another at A. The latter is at once brought to a dead stop until its predecessor has reached C, when it is at once allowed to proceed. It should be mentioned that the engine can be reversed when necessary, and that whichever way it passes over the contact makers the line just quitted is always blocked.

Professors Ayrton and Perry also make the train itself automatically record its position on the line. Along the railway a thin insulated wire runs to the signal station, and is connected with a galvanometer, to which is attached a pointer. This is placed behind a map of the line, and as each section is entered, the shadow which it casts moves on when the train itself advances, stops when the train stops, and backs when the train backs, the mechanism being effected by the passing train putting the insulated wire in connection with the ground successively at each contact box, and by the galvanometer being so arranged that the position of its pointer indicates the place where this temporary earth connection is made. Fig. 4 shows such map, which depicts three sections, and tells us that no train is on the section Uffington to Helpston; no train on the section Walton to Peterborough; but that a train is on the section Helpston to Walton, at about one-third mile from Helpston.

Our illustration represents the working model of the railway shown by Professor Ayrton at his recent lecture at the Royal Institution. It is divided into four sections, each eleven feet long. The electricity is generated by a magneto machine, A, worked by a gas-engine, B. On the line are placed small models of a passenger carriage, say to represent an express train, and of a goods truck. C, D, E, F, are current indicators, and are merely for showing that an electric current is also supplied to that section of the line on which the train is running. *a*, *b*, *c*, *d*, are the contact makers at the ends of each section. One of these is shown enlarged in Fig. 2. The upright lever of this contact maker is moved and locked by the train in passing in either direction, and its depression fulfills three objects: (1) It puts the current on to the section the train is entering; (2) it unlocks the lever of the preceding contact-box, and so takes off the current from the section the train is just leaving; (3) it sends a current through whichever of the electro-magnets, *e*, *f*, *g*, *h*, is in the rear of it, attracting down the armature of the electro-magnet, and so blocking the section. Fig. 1 shows the blocking electro-magnet enlarged. In actual practice, however, the contact-maker in Fig. 2 would be liable to be broken by the shock of the moving train, and is consequently replaced by the contact-maker in Fig. 3. In this two plungers are depressed in succession by the flange of the wheel passing over two long slightly curved pieces of steel, which gradually depress springs, and prevent the plungers from being damaged by the shock. The order in which these plungers are depressed has the same controlling action as the direction in which the lever of the contact-maker shown in Fig 2 is moved by the passing train.

In conclusion we may add that when exhibited the working of the model leaves nothing to be desired. When a carriage is allowed to run on the line, it can be stopped or reversed in a moment by simply turning a handle. When also the goods truck is starting ahead of the express, the latter, although traveling at great speed, never fails to stop dead on entering the section in the rear of the more slow-moving carriage. On the goods truck, however, being shunted to the siding, shown in the illustration, the express at once runs round and round at full speed.

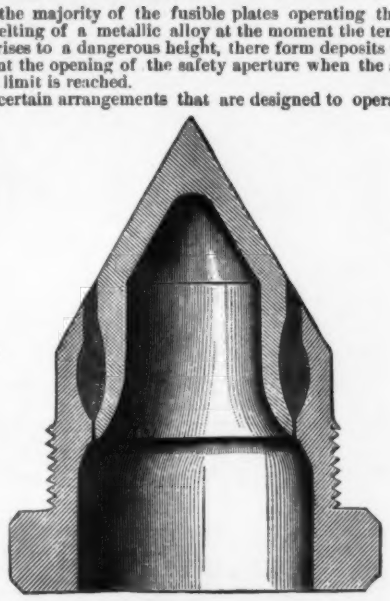
The employment of such an electric railway not only greatly increases the safety of traveling, but, as proved by Professor Ayrton in his lecture, also greatly diminishes the cost, for the gain arising from the absence of a locomotive-engine combined with the lightly-made permanent way, which then becomes possible, is far greater than the loss arising from the waste of power in electric transmission.

Our portraits are from photographs—Professor Ayrton by the London Stereoscopic Company, Cheapside and Regent Street; Professor Perry, by Messrs. Chancellor, of Dublin. —*The Graphic.*

FUSIBLE SAFETY-PLUG FOR BOILERS.

IN the majority of the fusible plates operating through the melting of a metallic alloy at the moment the temperature rises to a dangerous height, there form deposits which prevent the opening of the safety aperture when the anticipated limit is reached.

In certain arrangements that are designed to operate on the same principle, the plug becomes exposed to the action of the gases from the fire-place, and these would gradually destroy the fusible metal. Mr. Henry Adams, an engineer of London, remedies these two troubles by the adoption of a form of plug shown in the annexed cut. In this device the conical surface of the interior cannot retain any deposit. Besides, the joint between the cone and its seat is reduced to a minimum on the side toward the fire-place, so that the fusible metal is well protected.



NEW SAFETY PLUG.

The cut shows the actual size of a plug necessary for the most generally used Cornouailles boilers. These plugs, which have been adopted by a large boiler insurance company of England, may be made of any dimensions so as to give such an orifice for escape as may be desired.

ON CRACKS AND ANNEALING OF STEEL.

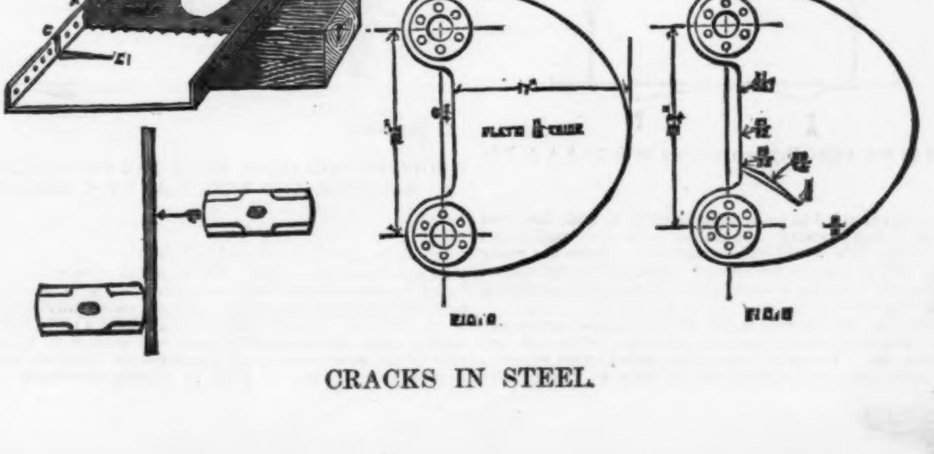
THE following paper was read by Mr. A. C. Kirk, at the recent meeting of the Institution of Naval Architects, London: It is well known that occasionally steel plates have been cracked in a way very mysterious and unaccountable, and the general cause to which it has been attributed was want of annealing, or that process done badly. About the middle of June last year Mr. Kirk had his first experience of these cracks. The plate—a back tube plate—had been flanged at the smith's fire, heated all over in the furnace, straightened up, and allowed to cool in the usual way. The centers of the tube holes were marked off for boring, and two men were deepening the centers for the boring machine with a flogging hammer and punch, when the plate cracked and opened as shown at C D, Fig. 1, showing that there was a strain at that point on the plate. The plate simply cracked, and was not in the least reduced in thickness on either side of the crack, showing that no extension previous to fracture took place, in this respect agreeing with all the best information he has been able to collect of similar fractures which have occurred elsewhere. It is difficult to see how a material which can stretch 25 per cent. under a strain without fracture can break with no extension at all. This is confirmed by many things we see often; notably so in steel rivets shrinking and never breaking, flanged boiler fronts, with holes flanged in them, which have been heated and worked piecemeal, and which he has never found to crack, though tumbled freely about before they were put in the furnace and straightened; virtually annealed. From this we may deduce that when such fractures occur there is a presumption that there has been from the beginning—from the ingot state probably—a line of weakness, along which the fracture takes place. As this seemed worth testing he had the plate drilled across at the line A B, shown on Fig. 1. The remainder of the plate he had heated in the furnace all over to a bright red, removed, and laid outside, as in Fig. 1, and cold water and wet cloths applied to the shaded part marked "cold," till it was quite cold. At this time the unshaded part, marked "hot," was hot enough to just set fire to straw. The whole plate was now cooled as quickly as possible. Thus the upper part of the plate was placed in tension to the utmost degree possible by unequal cooling, and if steel must break when that is done it ought to have cracked in the flange marked "hot." Lying on a block of wood he had it struck six times over various parts of its surface by full blows of a 28 lb. hammer, which produced no effect. He then had a 28 lb. hammer held up against the flange at one side and struck four times with another, the only result being to bend the flange slightly. The same thing was repeated in the middle of the flange at the "hot" end, with the same result. He then had the flange at hot end at E, Fig. 1, nicked deeply on edge and both sides with a rod chisel and 28 lb. hammer, after which the plate was struck six blows on the surface without fracture. After that the flange was held up on one side of the nick by the same hammer and struck four times on the other side, without starting a fracture. He then had it next supported on two blocks under the steam hammer about 6 in. apart, and bent the part between these 3 in., still without producing a fracture. Thus sound steel put intentionally into the greatest state of tension possible, by unequal cooling, does not crack, and cannot be cracked. It has been stated that contraction tears a plate, the fracture then commencing at the edge and gradually extending into the plate, and that thus extension as in a simultaneous fracture right across a piece of steel could not be expected. Mr. Kirk tried this. He prepared a plate of mild steel, shaped as in Fig. 2 with the object of tearing it by direct tensile strain. The thicknesses decreased in all directions toward the place of fracture, but more especially along the edge of the plate and of the fracture, as will be seen on reference to Fig. 3. The plate stretched between centers 1¼ in., when rupture took place under a load of 80 tons. The action of stress throughout the material is distinctly marked in clearly defined lines by the cracking of the surface skin or scale.

The discussion on Mr. Kirk's paper may be summed up in the remark that good uniform homogeneous steel does not behave in a mysterious manner, and that when steel does crack as shown in the paper it is because of an incipient crack or flaw which has had its origin in the ingot, as in a blowhole or impurity, and which has followed it in all the subsequent working.

COUNTRY ROAD MAKING.

THE main point to be kept in view from first to last, in making country roads, is drainage. No road can be a success without good drainage, whether natural or artificial, surface or underdrain. The latter is preferable, for a soil naturally porous enough not to require an underdrain will remain so for a comparatively short time only on a traveled road. The accumulating dust and dirt soon prevent free drainage. Water should not be allowed to accumulate at any time, or for any length of time, on the road-bed or in the side ditches. The road-bed cannot be kept dry with stagnant water in the side ditches. These ditches should never be so deep as to cause a wagon to tip over if the wheels on one side should accidentally run into it. If the grade is such as to require a deeper ditch it should be in the form of an underdrain. A three inch tile laid through the center of the road-bed in the direction of its length, at a depth of three feet below the surface, with an outlet every forty rods, would be beneficial to almost all roads, no matter through what soil they run. In spring and fall, and in open winters, the benefit of a center underdrain is beyond question. The inclination should be 1 to 125 in the direction of its length to secure effectual drainage. A similar drain under each side ditch would be money well invested.

In most soils it is a detriment to roads to use the surface soil in their construction. It would be better to scrape it



CRACKS IN STEEL.

off to be used to fill up hollows, or if the country is level, it had better be used by the adjoining land-owners as a top-dressing on their lands. Almost any other use that can be made of it would be better than to have it on the road to form mud with every shower. In grading a road, and after it has received the desired convex form, the bed should be thoroughly plowed a number of times in order to thoroughly mix the material and have it settle evenly. This is an important feature, though seldom practiced. Gravel is the best dressing for country roads, if of uniform material, free from soil, though a light mixture of clay helps to bind it. All stones larger than a hen's egg should be carefully removed. If on a much traveled road, the gravel should be at least one foot deep in the center, carefully leveled off by means of shovel and scraper. Rolling with heavy rollers is very beneficial. If the gravel is put on in fall the rains will help to settle it more effectually than if put on in summer, when it often remains in a loose state for months.

Limestone or flintstone chips, cobble or large stones of any kind are unfit for top-dressing of roads, to fill shallow holes or ruts. They can be used by first excavating the road bed from one-half to two feet deep in the center, gradually rising toward the ditches; this can be filled up with stones, the larger ones set on edge, until the bed has the desired form, when the upper layer should be broken up fine, the largest not to exceed two inches in diameter. A thin dressing of gravel may be added, and the whole thoroughly rolled with a heavy roller. This is one way of using stone in road-making, though in most cases too expensive for country roads. Large stones scattered through a road bed are sure to come to the surface in time by the frost raising them, and allowing sand or soil to deposit itself beneath; or if struck on one side by a wheel, the opposite side is raised, and in time it is on the surface, an impediment to every passing vehicle. Every time a wheel strikes a stone it suffers to the same extent as if struck with a sledge, to say nothing of the extra force required to carry the wheel over the obstruction. *Remove all stones from the roadway.*

The limit of practicable inclination varies with the character of the road. For the best roads the limit is one in thirty-five. The advantage of a level road over an inclined one is superior to the cost of increased length in avoiding a hill. The resistance of gravity at different inclinations, irrespective of the same character of the road, is as follows:

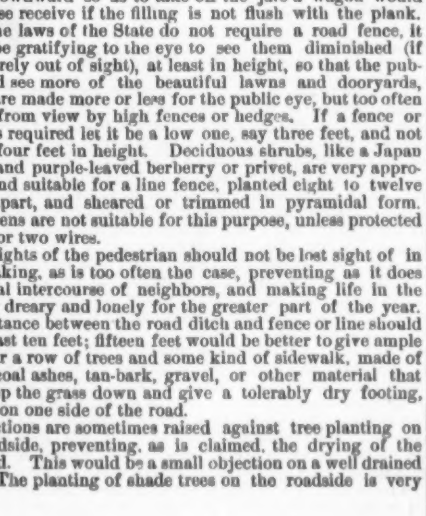
Rise.	Load.	Rise.	Load.
1 in 100	0·9	1 in 26	0·54
1 in 50	0·81	1 in 24	0·50
1 in 44	0·75	1 in 20	0·40
1 in 40	0·72	1 in 10	0·25
1 in 30	0 64		

That is to say, if the draught on a level road for any given load would be 1, on an inclination of 1 in 100, only nine-tenths of the load could be hauled with the same force. On a rise of 1 in 24, only one-half the load could be hauled with the same force, etc. All roads should primarily be laid out on as level land as possible; this is of first importance, for as seen by the above table, the greater the use made of such a road the greater the loss to the public, according to the grades. In a hilly country, roads should not follow the land lines, when as indicated by the above table the grade would not favor a first-class road, but should follow such grades as are more favorable, even though the road will be made longer thereby; the economy in the end will be vastly greater.

Except where timber is very abundant, iron bridges on heavy stone foundations are the most economical. The end plank or planks of bridges, as well as sluiceways, should bevel downward so as to take off the jars a wagon would otherwise receive if the filling is not flush with the plank. Since the laws of the State do not require a road fence, it would be gratifying to the eye to see them diminished (if not entirely out of sight), at least in height, so that the public could see more of the beautiful lawns and dooryards, which are made more or less for the public eye, but too often hidden from view by high fences or hedges. If a fence or hedge is required let it be a low one, say three feet, and not exceed four feet in height. Deciduous shrubs, like a Japan quince and purple-leaved berberry or privet, are very appropriate and suitable for a line fence, planted eight to twelve inches apart, and sheared or trimmed in pyramidal form. Evergreens are not suitable for this purpose, unless protected by one or two wires.

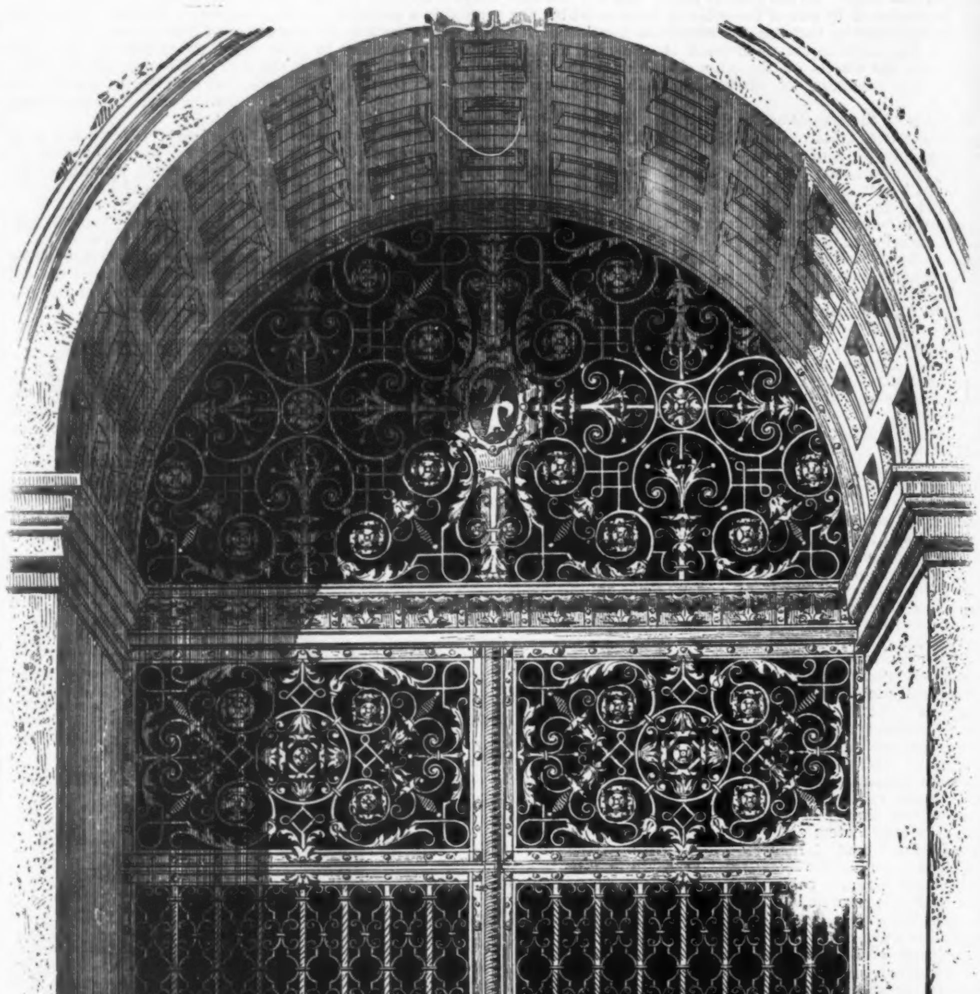
The rights of the pedestrian should not be lost sight of in road making, as is too often the case, preventing as it does the social intercourse of neighbors, and making life in the country dreary and lonely for the greater part of the year. The distance between the road ditch and fence or line should be at least ten feet; fifteen feet would be better to give ample room for a row of trees and some kind of sidewalk, made of plank, coal ashes, tan-bark, gravel, or other material that will keep the grass down and give a tolerably dry footing, at least on one side of the road.

Objections are sometimes raised against tree planting on the roadside, preventing, as is claimed, the drying of the road bed. This would be a small objection on a well drained road. The planting of shade trees on the roadside is very generally conceded to be an improvement to both the road and adjoining property. Particular avenues of well-grown trees often gain world-wide reputation. There are many kinds of trees suitable for roadside planting, but for a select list the following are reliable, given in succession according to their merits:



Road 60 feet wide—Between Ditches 25 feet—A A A, Tile Drains.

White elm, tulip, scarlet maple, Norway maple, hard maple, horse chestnut, catalpa (*speciosa*), chestnut, white oak and English elm. The tulip, hard maple, and chestnut require a naturally deep well drained soil in order to thrive. The best effects are obtained by planting one kind for long distances, and neighbors should club together and decide on a tree, and have no other planted in a given section of road. Apple trees are very objectionable for this purpose, being naturally low and spreading. The continued trimming up required to keep the branches out of the way soon ruins them. Fruit trees are out of place on the roadside. The proper distance for planting is eight to ten feet from the line and thirty feet apart. Trees should be well protected by stakes or boxes for a few years. Nursery-grown trees are the cheapest in the end.



WROUGHT IRON GATE, FROM THE IMPERIAL OFFICE OF JUSTICE IN BERLIN, DESIGNED BY VON MOERNER, AND EXECUTED BY E. PULS, ART METAL WORKER IN BERLIN.—*The Workshop.*

It is to be hoped that "working out the road tax" will soon be a thing of the past. The road tax should be collected in cash with and at the same time the general tax is collected, and made payable to the man whose duty it is to let the contract for road-making in each district to the lowest bidder, under written specifications and subject to inspection by the commissioner of highways, or whatever such person's title may be.—*C. D. Z., in Country Gentleman.*

RIPON CATHEDRAL.

The quiet little country town of Ripon, in the north-west part of Yorkshire, was made the see of a bishop in the seventh century, under the Saxon kingdom of Northumbria; but this bishopric remained in abeyance more than a thousand years. It was revived in 1836, the Diocese including the deanery of Craven, part of the deaneries of Ainsty and Pontefract, and those populous manufacturing districts of the West Riding which contain the towns of Leeds, Bradford, Halifax, Huddersfield, and Wakefield.

The Cathedral at Ripon has arisen from a Benedictine monastery founded by the monks of Melrose, but which gave place, under the Normans, to a convent of Augustinian canons, and this was converted, after the Reformation, into a collegiate church. The Archbishops of York held the manor of Ripon, and often resided there, in the twelfth and thirteenth centuries, when they built the older parts of the existing cathedral, in the Transition and Early English Gothic

RIPON CATHEDRAL.—DRAWN BY S. READ.

RIPON CATHEDRAL.—DRAWN BY S. READ.

styles; but parts of the choir, and the nave, are Perpendicular architecture, of the fifteenth century. The chapter-house is a Norman building. The west front, not shown in Mr. Read's drawing, is a singularly pure example of Early English; it presents a central gable, 103 ft. high, between flanking towers somewhat higher, divided by flat buttresses from the central compartment. The grace and harmony of the whole design, though its component parts are simple, will be appreciated by a correct taste; but this front is too narrow for an effective view; and the artist has preferred a view from the south-east, showing the choir and south transept, with the low central tower.—*Illustrated London News.*

A THERMOGRAPH.*

A NEW APPARATUS FOR MAKING A CONTINUOUS GRAPHICAL RECORD OF THE VARIATIONS OF TEMPERATURE.

By G. Morgan Eldridge.

The instrument under consideration is a thermograph for recording the atmospheric temperature, the fluctuations of which are much less regular and more frequent than one who has not made a study of it would suppose. It records the temperature directly from the column of mercury in the tube of a thermometer by dots or perforations upon a sheet of paper previously ruled with degrees and hours.

Its principal parts are, as shown in Fig. 1 of Plate:

1. A thermometer in the form of an ordinary mercury thermometer, but open at the top of the tube and having a wire entering the bulb and connected to one pole of a battery, the other pole of which is connected to the mechanism of the instrument.

2. An upright cylinder, revolving by clockwork, covered with a paper which is divided vertically into twenty-four parts by lines representing the hours, and horizontally by lines representing the degrees.

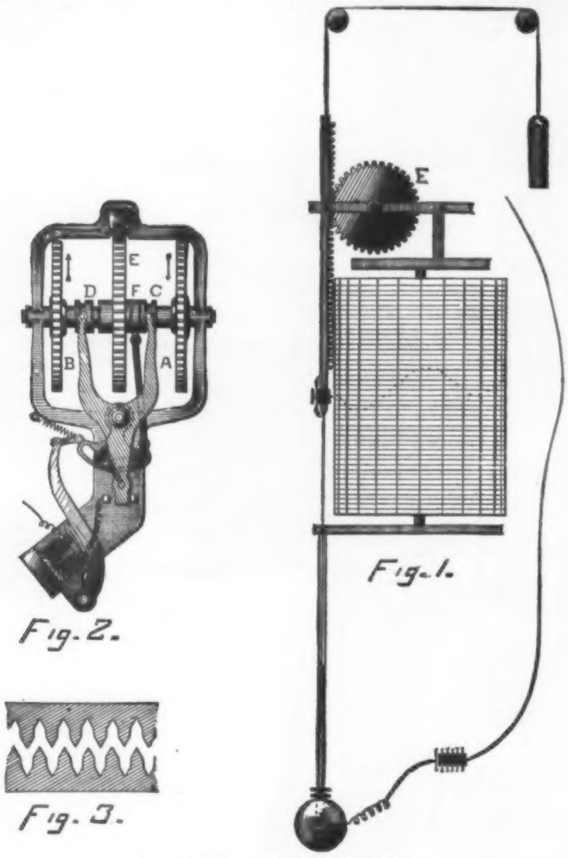


Fig. 1.

Fig. 2.

Fig. 3.

IMPROVED THERMOGRAPH.

3. A bar raised and lowered by mechanism driven by clockwork, furnished below with a needle entering the tube of the thermometer and carrying a pencil—or preferably a point—driven forward by a small electro-magnet when the circuit is closed by the needle entering the mercury, and then making a mark at the proper place upon the paper and indicating the temperature.

The bar carrying the needle rises about half an inch from the point at which the needle leaves the mercury and then descends until the needle again touches the mercury, whether that in the meantime shall have risen or fallen, when the point makes its mark upon the paper and the bar again commences to rise.

This movement is accomplished by the mechanism shown in the drawing, of which only the wheel, E, gearing into the rack upon the needle bar, is shown in Fig. 1, but which is shown in full and upon an enlarged scale in Fig. 2, which is a top view. The two wheels, A and B, are moved by clockwork (not shown) and are constantly revolving in opposite directions, as indicated by the arrows. These wheels are not attached to the shaft upon which the wheel, E, is fixed, but are attached to sleeves which move without affecting that wheel except when they are joined to it by the clutches, C or D. They are so geared that when the wheel, E, is joined to them its rim moves at the rate of half an inch per minute. Upon the shaft with the wheel, E, is also a loose sleeve, F, which is free when the clutch, C, is not in action, but which moves with that wheel when that clutch is on.

The levers actuating the two clutches unite and move upon a common pivot, from which point they extend as an arm, which is capable of a lateral movement between two stops, bringing one or the other of the clutches into action.

Opposite to the wheel, E, the needle bar passes through a guide which is furnished on the back with a small wheel taking the thrust of the gear and reducing friction. For a lower guide the needle bar is furnished on each side with a rod parallel to the needle, and of nearly the same length. These rods are at such distance apart that they pass clear of the thermometer tube. They are not shown in the drawing, as they would lie directly in front of and behind the needle and tube.

The teeth of the clutches are partly V-shaped and partly square, or nearly so, as shown in Fig. 3; that is, they have slightly tapered sides but V-shaped points and bases, so that they enter freely, as entirely V-shaped teeth would do, and when in action they have no outward thrust. The V-shaped base strengthens the tooth and admits the point of the opposite tooth.

A very small spring on each side of the sleeve, F, holds it out of gear while the clutch, C, is off.

Beneath the clutch arm is a pressure spring, one end of which presses against the end of the arm and the other against a plate moving upon the same pivot with the arm, which plate also is capable of a lateral movement between its stops.

If this spring plate is moved in either direction to its stop, carrying with it the base of the spring, the clutch arm will be moved in the other direction and the clutch on that side will be brought into action; and if the position of the spring plate with the base of the spring be reversed, the position of the clutch arm will be reversed—that clutch will be disengaged and the other one will be engaged—the wheel, E, being moved and the needle bar raised or lowered accordingly.

To the sleeve, F, is attached an arm which is connected by a draught rod to the spring plate.

When the clutch, C, is in action—as shown in the drawing—connecting the wheel, A, with the wheel, E, and the sleeve, F, raising the needle bar, the arm of the sleeve, F, draws upon the spring plate—moving to that side the base of the reversing spring, which, when its base has passed the line between the pivot and the end of the clutch arm, presses that arm to the other side, disengaging that clutch, loosing the sleeve, F, engaging the other clutch, and reversing the motion of the needle bar, which now descends.

The length of the arm on the sleeve, F, is such that when the needle-bar has risen half an inch the spring-plate is moved over and the clutch-action is reversed.

When, by descending, the needle is brought in contact with the mercury and a circuit is made, the large electro-magnet, thus vitalized, attracts its armature, which is attached to a lever connected with and drawing upon the spring-plate, and moves the base of the reversing spring to that side, changing the position of the clutch-arm and reversing the action of the clutches and the movement of the needle-bar, while at the same time the recording point upon the needle-bar is, by its electro magnet, driven into the paper and the temperature is recorded upon the scale.

The sleeve, F, being loose, yields to the movement of the spring-plate, and is afterward held by its clutch, and acts as before.

The action of the large electro-magnet is supplemented by that of a spring drawing upon the same side of the spring plate, whose strength is such that it is not quite sufficient of itself to overcome the thrust of the reversing spring, but whose force is greatest when that of the electro-magnet, by reason of its distance from its armature, is least, the greatest possible portion of the work being thus put upon the clockwork and the least upon the battery.

This spring aids the electro-magnet, but does not in anywise reduce the effect of the reversing spring in holding the clutch to its work; so long as the base of that spring is unmoved its action is unimpaired. The resistance of these springs occurs only during the ascent of the needle-bar, which is, therefore, counterpoised to excess, and the resistance and the motion are thus rendered uniform. By reason of the form of the clutch-teeth before described there is no outward thrust upon the clutches while in action, and hence the reversing spring requires only to be strong enough to throw the arm over and to shift the clutches. The stop of the clutch arm next the electro-magnet is an insulated plate to which the battery-wire leading from the magnet is connected, so that as soon as the arm has left the stop the circuit is again broken, although the needle may for a short time remain in contact with the mercury; the recording point is at once withdrawn, and thus makes upon the paper a single perforation, which must be a true record of the position of the mercury in the tube, unaffected by friction or other disturbing cause, since this action must always take place at the moment of contact of the needle with the mercury, and these dots or perforations are repeated at the end of each interval of time required for the needle-bar to ascend and descend the required distance, which will be about two minutes with the wheel motion designated.

The graduation of the scale upon the paper must correspond with the movement of the mercury in the tube of the thermometer as accurately as the graduation of the scale of an ordinary thermometer corresponds with the movement of the mercury in its tube.

If but one instrument of this sort is to be made this is very easy, the rate of motion is ascertained, a scale is made to fit it, and the paper is ruled to that scale.

In all thermometers heretofore made the scale has been made to fit the tube, but if more than one of these instruments is to be made it becomes necessary, or at least very convenient, to have one set of ruled papers that will fit all the instruments, and it then becomes necessary to reverse the practice and to make the tubes to fit the scale.

The rise and fall of mercury in a thermometer depends upon the proportion between the diameter of the tube and the volume of mercury in the tube and bulb, and while it is possible to construct these parts in such proportion as to obtain proximately a given motion, it is not possible thus to obtain it exactly.

The tube and bulb are made in separate parts, as shown in Fig. 1, of such size that when the tube is thrust half way into the bulb the volume of mercury filling the tube half way at 32° Fahrenheit is as nearly as may be properly proportioned to the diameter of the tube. If now there be found too much motion the capacity of the bulb is diminished by thrusting the tube further in, and *vice versa*, and the proper height of mercury at 32° for that purpose is marked upon the tube.

Mercury exposed to the air will slowly form a coating of oxide upon its surface. To prevent this a small quantity of glycerin or of oil free from oxygen is placed in the thermometer tube above the mercury. If, notwithstanding, the oxide shall accumulate to an inconvenient extent the observer in charge of the instrument will remove the thermometer from its place, and will put the bulb in warm water until the oxide is floated off. He will then supply the loss with pure mercury, determining the proper quantity by immersing the bulb in broken ice, when the mercury column should stand at the mark for 32°.

The whole apparatus, except the thermometer itself, can be inclosed and so protected from the weather and dust, while the thermometer is exposed to the air below.

The system is equally applicable to a barometric record, in which case, on account of the small range of motion, the needle-bar is connected to a lever, thus increasing the range of the record.—*Franklin Journal.*

PORCELAIN: ITS HISTORY, MANUFACTURE, AND DECORATION.

By M. Chas. Lauth, Director of the Factory at Sèvres.

The uses of porcelain are so numerous and its employment has become so general, that there are but few persons still living who can recall the time, although it is not very long ago, when porcelain was considered an object of luxury and only faience (earthenware) was in common use.

What advantages has porcelain over faience? What are the methods by means of which its production and decoration are accomplished? These are points which I shall hope to make clear to you in the following discourse.

I shall, therefore, divide my subject into three portions: the first will treat of the nature of porcelain and of the history of its discovery; secondly, the chief points of its manufacture will be described; and finally, the various means employed for its decoration will be given.

It is well known, in a general way, that porcelain is the product resulting from the action of fire upon a certain kind of clay. In what way does it differ from baked clayware and faiences? No one can mistake them when their external appearance is examined. Here is an object of ordinary baked clayware; you see its color, and you are aware that its resistance is slight.

Faience in appearance resembles, as you see, porcelain: it is white on the outside, and sometimes so internally. Still it may be scratched by a knife and is quite opaque. On the other hand, porcelain is always white, perfectly transparent, and excels the other two products in being harder than steel. This last particular is of considerable importance from a domestic point of view; for pieces of tableware which are injured by knives soon become unclean; they diffuse a repulsive odor, and finally they exert a deleterious influence on the human health, in that the white covering over the clay is poisonous.

It will be impossible, as you can readily understand, to describe to you in detail the manner of production in all of the potteries; for such a purpose a complete course in ceramics would be necessary. It will be sufficient to tell you that the earthenwares are obtained by the simple action of fire on ordinary clays; that the faiences are baked clays, more or less colored, covered with a lead enamel which is rendered opaque in consequence of the tin it contains (their use for domestic purposes is dangerous on account of the lead contained in the enamel), and finally, that the hard porcelain is made from a white clay, kaolin, and a special glaze or covering made from feldspar. The kaolin, which is a natural hydrated aluminum silicate, is completely refractory and opaque; the resisting quality of the porcelain is due to this substance. The feldspar (or the pegmatite) are silicates of aluminum and potassium, which fuse at a very high degree of heat into a beautiful transparent glass. Hence when a small quantity of feldspar is mixed with kaolin, and this mixture covered with a layer of feldspar and exposed to high temperature, the feldspar will melt, and in so doing, it imparts to the opaque clay a transparency which is greater or less according as it becomes mixed with the body of the ware and as it comes in contact with the portion on the surface. The beautiful glistening, which you are all familiar with, is due to this substance. In reality, the procedure is not so simple, for it is more than a mere physical action that we have before us; there is, to be sure, an attack on the clay by the feldspar, but, in addition, there is a true chemical reaction, which gives rise, beyond a doubt, to the formation of a crystallized silicate;* all of these elements combine together more or less, but of course it will be im-

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* A Paper read at the Stated Meeting of the Franklin Institute, April [illegible], 1882.

* With the aid of the microscope, it is possible to detect the presence of crystals in the very fine laminæ of the porcelain.

possible to describe the details at present, for to do so would extend the time of this lecture too long.

How shall we describe the manufacture of porcelain? For its perfect understanding we must be familiar with the clay; we must know that this kaolin is the result of the decomposition of feldspathic rocks, which from causes as yet but little comprehended, have been deprived of their potassium silicate, becoming aluminum silicate. These two compounds are found frequently associated together in nature, and so it is easy to explain how the originators of this industry came to employ them together. A still more interesting point of investigation would be to determine how the conception of the manufacture was first realized. The feldspar does not melt except at a very high heat—about 1,600°. How did the idea originate that this rock would melt? How was it that means were devised to obtain this elevated temperature in these vessels of such large dimensions, and which heat is only resisted by refractory clays of the very first quality?

These are questions which are not easy to solve. I have thought it best to allude to them because I have been unable to restrain my admiration of the sagacity, the patience, and the audacity even, which were displayed by the original investigators, who without any serious scientific knowledge, were able more than a thousand years ago to create an industry whose difficulties to-day are still very many

The origin of porcelain goes back to very great antiquity in China. It is certain that, for at least a thousand years, the Chinese have been familiar with its manufacture. There are some authors who date its discovery fully fifteen to eighteen hundred years ago, but from the conscientious studies which are daily being made on this point, I can not permit myself to attribute its origin to an earlier date than the one mentioned above.

The first specimens that reached Europe were probably procured by the Venetians, near the close of the thirteenth century. Charles VII., King of France, received about the middle of the fourteenth century, a present from the Sultan of Babylon, consisting of Chinese porcelain; but it was not until the following century that the importation of these Oriental products by Portuguese and Dutch merchants began to assume any significance. It is easy to understand how the arrival of such objects produced great astonishment and admiration of an unknown material, adorned with brilliant colors, in various shapes, at once both strange and elegant. Nor is it difficult to understand how immediately savants and artists increased their investigations in this direction; and it must not be forgotten how, at that time, chemistry had hardly begun its existence as a science, and there was nothing, so to speak, which could be used as a guide toward the solution of their desires. Toward the end of the seventeenth century a discovery made by two Frenchmen calls for our highest admiration.

I refer to that of the tender porcelain. The honor of having been the cradle of this discovery is disputed by Paris and Rouen, but whether it be Louis Poterat or Reverend to whom we are indebted, we should none the less acknowledge with pride and gratification the names of the distinguished workers who have bequeathed to France so charming an industry, whose products are still sought after with the most intense eagerness by artists and collectors.

The French characters of this discovery must be insisted on, for in a time when from envy, skepticism, or by discouragement, so many seemed disposed to doubt the genius of our country, our efforts should be increased to honor by proper recognition the memory of all those by whom the glorious reputation of our France has been advanced.

The tender porcelain must not be confounded with ordinary porcelain, for it contains neither kaolin nor feldspar. It is an artificial product, almost a glass, in fact, and is obtained from a frit which is essentially composed of sand, lime, potash, soda, and a small quantity of calcareous marl. This mixture is made plastic by the addition of black soap or some mucilaginous substance, then formed and fired without any enamel, after which it is covered by a glaze consisting of silica, lead, potash, and soda. The beauty, the perfect luster, the ease with which vitreous colors can be fixed on this ware are prominent qualities which form for this tender porcelain a combination that is very favorable for its decoration. You are all familiar with its artistic value, and I shall content myself by exhibiting to you a specimen which will serve to recall to your minds the characteristics of this beautiful ware.

The discovery of the French tender porcelain did not stop the investigations of savants and potters, who soon saw that it did not possess any of the characteristics of Chinese porcelain. By a fortunate accident the discovery of a deposit of kaolin was made in Saxony (1709), and in consequence the honor of erecting the first European factory of hard porcelain was, according to Böttger, at Meissen. It was only fifty years later (1758) that Guettard, at Alençon, and then Mme. Darte, at Saint-Yrieix, near Limoges (1765), discovered our French deposits, and this fact explains how that, notwithstanding the discoveries and researches of our compatriot Hanong, the industrial manufacture of hard porcelain in France did not take place till a half a century (1776) after the foundation of the German works.

The tender porcelain soon succumbed before the harder variety; this was certainly a misfortune from an artistic point of view, for the newer porcelain was not fancied by the decorator. But it must not be forgotten that, at that time, it was necessary above all things to create an industry which should be free from any objectionable or dangerous manipulations, and I believe myself to be entirely correct when I say that it is the illustrious Brongniart who has rendered our country an enormous service by increasing, with all the efforts of his mighty intellect, the study of the manufacture of the kaolinic porcelain, and to which, thanks to his learned discoveries, his methodic investigations, his admirable publications, a scientific basis has been established which is impregnable.

Kaolin, in its natural state, is never found entirely pure; it is always more or less contaminated with variable amounts of sand, undecomposed feldspar, etc., and as it is absolutely essential that the mass should always be precisely identical in its composition, it is necessary to first purify the kaolin. To that end, the mass which I now exhibit to you is completely pulverized, then washed with water, and by a series of successive levigations the products are separated into the different varieties. The clay deposits itself very slowly, and is the first to be removed; in this manner it is quite easy to obtain it almost pure. The latter products are ground in mills, and in their turn are used to make up the composition of the mass.

The nature of the porcelain, its physical and chemical properties, vary to an almost infinite degree, according to the proportion of the two constituting elements (kaolin and feldspar), as well as by the addition of other matters, such as lime, silicious sand, pieces of broken pottery, etc., which are frequently made. Each country, or better, each factory, has its own particular composition, which is based on the uses to which the porcelain is destined, according to the degree of resistance which is required for the ware, and also dependent upon the variety of decoration for which it is intended. As a general rule, the porcelain is more dense according as it contains more clay, and so requires a higher heat for its firing; on the other hand, if the proportion of feldspar be augmented, the mass becomes more fusible, and the degree of heat requisite for its firing less; then it lends itself more readily to the hands of the decorator, but its plasticity and the ease with which it may be worked diminishes rapidily.

The mixture of the different ingredients adopted must be perfect; this is effected by treatment with water, which, by means of mechanical agitators, brings the entire mass into intimate contact, after which it is allowed to settle to the bottom of the water. The liquid is then decanted off and all excess of water removed either by means of filter presses, a vacuum, or else by passing the mass over beds of some porous substance, such as plaster or the like.

In this way a mass is obtained which may be preserved for a shorter or longer time, and which, as it ages, becomes more and more plastic. It is pretended that certain silicious masses which are but slightly plastic are preserved by the Chinese for as long as a century, but this statement is very far from being proven. Experience elsewhere has shown that the qualities requisite for the production of a good paste may be obtained by thoroughly kneading or treading the mixture. Most excellent mechanical apparatus have been designed for the accomplishment of this aim.

The end to be achieved in the treading or kneading of the mass is not only to make it more plastic or more completely homogeneous, but also to exclude any air bubbles which may have formed in it, for if this precaution is not observed, later on, when the objects are being fired, the bubbles will swell, causing serious accidents.

Having now obtained our clay in a proper condition, it becomes necessary to fashion it into a suitable form; for this, previous study in the domain of sculpture is essential, as well as a thorough knowledge of the details of the manufacture. It is a serious mistake, and one which is frequently made, to believe that an article, of any form whatsoever, may be converted into porcelain. It seems to be forgotten, in so reasoning, that at the moment of firing the porcelain softens, and that, in order to prevent its collapse, it must be supported, and as it is covered with a molten glaze at that moment, it is necessary to ascertain the points of support in each object. These points must not be glazed, so that adhesion can be avoided, for otherwise they might lead to the destruction of the article.

Thus you are informed of one of the difficulties which exists in the manufacture of porcelain and one of the points in which it greatly differs from earthenware (faience). The fabrication of articles in porcelain may be accomplished by two methods totally different, *without moulds* or *with moulds*. We will begin by considering the first method, by means of which all forms that can be made on the potter's wheel are produced. The operation divides itself into two parts: the shaping or forming and the turning. M. Morin, one of our excellent workmen from the factory at Sèvres, will go through the operation before your eyes. He places a lump of the clay, proportionate to the size of the object which he desires to produce, and of which he has a drawing at his side, on the center of his wheel; the latter is then set in rotation by the action of his feet, then the lump is compressed with his two hands, making it broader and again narrower; finally, having brought it to a state of absolute homogeneity, an indispensable requisite, for fear of ultimate misfortune. When he thinks the proper result has been attained, the inside of the piece is hollowed out with his thumbs, then with his remaining fingers he widens the form of clay until a sort of cylinder is produced, which may be considered as the outline of the object which is being fashioned; at the same time he will show you how a horn, a vase, a bottle, or cup may be made by the same process.

These different objects are by no means completed, for they only represent approximately the form which they are intended to receive. They are allowed to dry, and this operation should be attended with every precaution, for the least hastening may cause the object to crack.

When the piece has reached the desired point, the workman again places it on his wheel, and the second part of his operation begins, viz., the turning, which has for its end the finishing of the object, to give it the proper thickness and the exact form required by the drawing, to produce the mouldings, the threads, in a word, the conventional ornaments with which it is to be decorated. You will observe that the tools which are used in the turning are of the simplest nature possible; they are only of value as they increase the skill of the workmen, and I take great pleasure on this occasion in rendering homage to the marvelous dexterity of the turners at the factory of Sèvres.

We have now reached the description of the second method, in which the use of moulds comes in. It is employed for the manufacture of objects which do not present a proper surface for turning, and as we shall see later on, it may be used for the production of very delicate objects, or, on the other hand, for such as are so large that they cannot be fashioned on the wheel.

Let us suppose that it is necessary to copy in porcelain a piece of sculpture, say, for example, this medallion obtained from the hands of a skillful sculptor. The clay model must first be cast in plaster, and in this mould, thoroughly dried, a round mass of the paste is laid, a crust, which is pressed with the very greatest of care and as equally as possible, the clay receives all of the details of the sculpture, and after a few minutes have elapsed, the plaster, having absorbed all of the moisture from the clay with which it was in contact, will become detached, so to speak, all by itself. If the mould has been perfectly pressed so that no hollow spaces are apparent, the operation has been successful, and perfect results are obtained, similar to the sample which I now show you.

But this is only an illustration of one of the simplest cases, when it desirable to obtain objects in *alto rilievo*, statuettes, busts, or these elegant groups, which are so highly appreciated, known as "biscuits de Sèvres," or those magnificent vases whose sculptural decorations are so often their chief ornament, then the case becomes a more complicated one.

If, for example, it became desirable to reproduce that charming Baigneuse of Falconet, the modeler in plaster would commence by dividing the object into a certain number of pieces, the quantity of which would depend on the possibility of the moulding; then he would prepare as many moulds of plaster as there were fragments. Each of these in their turn serve as moulds for the reproduction of the various fragments (but it is entirely unnecessary to go into the details of this portion of the manufacture, which is also otherwise complicated); then the different portions are united and the parts attached to each other by means of a paste suspended in water. At this junction the finisher takes up the process.

The moulding always leaves seams, and only imperfectly reproduces the delicateness of the sculpture. The finisher has as his aim the transformation of a roughly finished article into an object of art, and it is, thanks to the taste, to the intelligence, and the skill of its artists, that the factory at Sèvres has been enabled to produce these biscuits, which are frequently equal to the most precious marbles.

I cannot leave this subject without mentioning an important characteristic occurring to the porcelain at the moment of the firing—its shrinkage. At the time when the elements of the mass combine there is a diminution of volume in about the proportion 10 to 15 per 100, and it is this that is called shrinkage. I place before your eyes three specimens, one in the crude state, the second unfired, and the third completely fired; you will see the necessity of considering this quality—the slightest irregularity in the forming, an unequal pressing of the moulds, a difference in the condition of the clays, any resistance in opposition to the movement of shrinking, are among the causes which produce accidents, and therefore must be carefully guarded against; unfortunately they cannot always be foreseen and so provided for. The use of moulds is not always employed for the fabrication of pieces of sculpture, but as I observed a few minutes ago, it is also possible by a very ingenious process to produce, both rapidly and economically, some of the most varied objects: the process to which I allude is that of casting.

According to Brongniart, the process of casting was discovered in 1784 at Tournay; he himself having introduced a number of improvements.

Nothing can be more simple than the fabrication of small objects by casting. Here we have the mould of a cup in plaster; we pour the slip (that is, the porcelain mixture suspended in water) into this mould. The sides of the mould absorb the moisture with which they come in contact, and so the formation of a layer is determined, which is less fluid than the rest, and which attaches itself against the sides. When the thickness is considered sufficient, the excess of slip is poured out, and that which remains in the mould constitutes the cup. It is dried, and after a short time, when it has become sufficiently hard, it may be withdrawn from the mould without any fear of its being injured.

I will now circulate among the audience a number of these objects. You will notice that by this process it is possible to make a very light and extremely delicate article; you will also see that a very slight pressure of the fingers is sufficient to break it. This same process of casting is used at Sèvres for the manufacture of large pieces, but in such a case it is necessary to be very skillful.

For, when a mould of one meter in height and sixty centimeters in diameter has been piled and the excess of slip allowed to flow out from the lower opening of the mould, the mass, which is suspended against the walls (and which under such circumstances should acquire a thickness of several centimeters) has a tendency toward sinking and falling—the least movement will cause the loss of the article. It must therefore be avoided at all cost. But how to retain this mass in a condition almost liquid? My illustrious predecessor, Ebelmann, appears to have decided, in 1848, that the falling of the paste might be avoided by introducing into the mould a rubber bag, which was to be inflated as the slip was allowed to flow out, and so upheld the paste against the walls. It is so long since this idea was put into execution that no important traces of its application have remained to us. The process, actually used since 1857, is the one devised by M. Millet, the skillful superintendent of the factory at Sèvres. It was he, with the aid of an intelligent workman, who determined all the conditions necessary to make the result perfect. The method consists in directing into the interior of the mould, at the moment when the slip is passed out, a current of compressed air which entirely replaces the liquid, and maintains the paste against the walls. This plan, which seems so simple to-day, and which gives such excellent results, required long and laborious researches. More recently, the action of compressed air has been replaced by the action of rarefied air, which acts on the exterior of the mould, and in most cases makes the operation more practical.

In either case the result is the same; the paste is held against the sides, and the mould may be voided without danger, and will furnish a perfect piece. The absence of seams, the purity of outline, the nicety of surface, makes the process of casting so perfect that when it is necessary to produce an object of art, it is preferred far above that by moulds. The details of its manipulation are extremely numerous, no one of which can be neglected, and you will readily recognize the importance which is necessary to each one of them, if you but consider that a single defect hidden in the interior of a large piece, a bubble of air imprisoned, a lack of homogeneity in the clay, etc., none of which will be perceived until after the firing, when the article has been decorated and acquired a value of several thousands of francs, then the least mishap in the casting may ruin the entire work. This delicate operation is confided to-day at Sèvres to M. Constant Renard, by whom it is daily improved, and who has very kindly consented to cast one of these large pieces for your benefit—it will be performed at the close of the lecture.

The objects made by one or another of these processes which I have just sketched out for you have now reached the stage when it is transformed into porcelain; that is to say, submitted to the action of the fire, which shall combine the different elements of the paste and produce the fusion of a covering. The firing takes place twice: in the first operation, where the fire is relatively low (it does exceed 1,000 to 1,200 degrees), the clay is transformed into what is called biscuit. It has become very hard, sonorous, and extremely porous; it is in this condition that the enamel or glaze is applied to the ware.

This operation is of the simplest kind: it consists of a rapid immersion into water, holding in suspension the feldspathic (feldspar or pegmatite, according to the factory) rock which has previously been ground to an absolutely impalpable powder. However simple as the enameling appears, still it requires a great deal of care; it is very essential that the layer of enamel be of the proper thickness, not too much nor too little, for fear of accidents; it is necessary that this layer should be as uniform as possible, that there should be no swellings nor any thin places. These various qualities cannot be obtained by the dipping alone, they are always followed up with finishing touches made with the brush.

At last we have arrived at the final firing, the "strong firing," in which a temperature of 1,600 to 1,800 degrees is requisite in order to produce fusion of the feldspar.

A few details are desirable, so that you may understand the progress and the difficulties of this operation.

It is impossible to fire the porcelain while in direct contact with the flames, ashes, or the smoke; these would deteriorate its beauty. It is necessary, therefore, for the second firing, as well as the first, that the articles should be protected by suitable coverings; to these the name of seggars or saggars is given. They are vessels made from the most refractory clays, and within them, on suitable supports, the articles are arranged with the utmost care. You have not forgotten how that the porcelain, before becoming baked, shrinks; hence it is best to anticipate this shrinkage by inserting props in the seggars, as they are closed, so that all the parts which are liable to become weakened may be properly supported, but at the same time due precaution must be taken to prevent the supports from becoming attached to the articles themselves. It is not without resorting to all sorts of artifices that it is possible to accomplish this result, so that ultimately no visible traces of these supports are left on the articles.

I now place before your eyes two examples of these supports, the proper use of which frequently demands much skill and ingenuity from the workman.

Our samples are now incased, and ready to be conveyed to the furnace. Some of these are to be converted into the biscuit ware, the others, enameled, are to be subjected to the "strong firing." We now proceed to the furnace. A glance at this drawing and over this plan will enable you to understand of what it consists; at once you will notice that there are two kilns, an upper one for firing the biscuit ware, which is heated by the waste heat escaping from the lower kiln and penetrating into the upper compartment through flues in the vault; the lower division is used for the "strong firing" of the ware which has been dipped into the glaze—it is called the laboratory, and it receives its heat by means of the flames which ascend through a number of wide flues in connection with the same number of fire-places.

The seggars, filled with objects of all sorts, are arranged in the interior of the laboratory in such a manner that the articles may be rested as perpendicular as possible, and supported on props. When the furnace is completely filled, the entrance is closed by a double door of refractory substances, and the fire is lit in the different grates. The temperature must be raised very slowly and very regularly in order to prevent unequal expansion of the articles, which would tend to their destruction. The increase in the temperature is followed by observation through a number of small openings arranged for this purpose in the wall of the furnace, through which the degree of heat is determined; successively it passes the dark red, then the bright red—in its advance to the "strong firing" the supply of air is gradually diminished until it attains the orange, bright orange, and finally white heat is reached. This stage, at which the porcelain is very near its baking point, is reached, according to the apparatus used and progress made, in twenty-four, thirty-six, and sometimes even sixty hours. Unfortunately, thus far, no instrument has been devised as a precise and regular indicator of the heat in the furnace, therefore one is obliged to depend upon the general appearance of the firing, which is determined by means of small test pieces of both the biscuit and glazed ware. These are removed at regular intervals throughout the operation. A few hours before the end of the firing these indicators become glazed, but they break; that is to say, they crack as soon as they are cool. If the firing was to be stopped at that moment the contents of the furnace would inevitably be ruined, and the charge lost. The heat is therefore continued until the test pieces become perfectly glazed and transparent, and the previously described phenomenon no longer observed. From this time on the heat should be diminished for fear of injuring the porcelain or producing dangerous disturbances inside of the furnace.

In reality, it is a very delicate matter to select the proper time to stop the heat, for it is equally difficult to avoid both of these dangers at the same time.

When the firing is considered as complete, the fire is covered, all of the openings closed, and the furnace allowed to cool for four to eight days.

Thus far I have only spoken of the temperature which it was necessary to reach in the firing of porcelain; there is another point, equally worthy of study, it is the nature of the gases which exist in the furnace. If only white porcelain is to be baked, a reducing atmosphere is considered advisable, because the traces of iron, titanium, etc., contained in the clay, are carried off with a minimum oxidation, and do not color the mass yellow as is the case with the oxidizing flame. If, on the other hand, the porcelain is decorated, it is decidedly advantageous to have an oxidizing flame, and as, almost always, the two varieties are fired together, it is only by a series of experiments, as for example, the artificial introduction into the seggars of currents of gas appropriate to this or that object, that it is possible to arrive at a desirable result. In order to inform myself upon the nature of the gases which exist in the furnaces, I found it best to have one of our engineers, M. Anscher, make frequent analyses of the gases during firing. The Orsat apparatus was of great service to us in this undertaking.

The nature of the fuel differs considerably: various sorts of wood or coal may be used.

Of course it is impossible to represent the actual firing of the porcelain before your eyes, still I have thought it would be of interest to show you a practical method for the making of the firing tests in the laboratory. I have used for this purpose the well known furnace of M. Perrot, and I have had the satisfaction of proving that it is possible to bake the porcelain in about two hours. The use of this most excellent piece of apparatus has been of the greatest service to us, for by its employment we have been enabled to study an entire series of phenomena as yet little known, as well as to prosecute interesting experiments at different temperatures I would most thoroughly recommend its use to chemists and also to manufacturers, who, with its aid, can make their tests, and also employ it for the quick production of small and delicate articles.

You probably observed that at the commencement of my lecture I lighted my fire. By this time I presume that the firing has been completed, and so we will extinguish the gas. In about a quarter of an hour I will show you samples which have been glazed, made into biscuit, and fired before your eyes.

Gentlemen, I have tried to present to you, as succinct as possible, a review of the principal points in porcelain making, and now I desire to add a few words in regard to the processes used for the decoration and embellishment of this beautiful substance.

The art of attaching the colors to a piece of pottery is an entirely different process from that used for fixing the color on tissues, on wood, or on paper; the ceramic decoration requires special treatment, which distinguishes it from all other similar processes.

A perfect adhesion, an absolute resistance against the action of the atmosphere, and an enamel which cannot be distinguished from the object itself, are among the characteristic qualities of a beautiful ceramic decoration.

As the covering of porcelain is a rock, one of the hardest substances of the mineral kingdom, it is understood that in order to effect the adhesion of a color special processes are absolutely necessary. It is only at an elevated temperature that this result can be achieved, and so at the beginning this circumstance necessarily eliminates from the palette of the ceramic artist all organic or mineral colors which are not stable.

It is necessary to adopt the oxides, the metallic silicates, or the metals themselves.

The fixing of the colors is always the result of a chemical action, of a combination which takes place at a high temperature between the body or the covering of the ware and the substance used for its decoration.

Several methods, each one different, are used for this purpose; these are arranged under the two important heads: those which are decorated by the "strong firing" and those which are decorated in the muffle. The former method consists in the application of the coloring substances in such a way that they become fixed and developed on the ware at the same temperature as that of the firing of the porcelain itself. It is by this method that the results are obtained which are very highly esteemed, for, as the enamel covers the color, an extreme brilliancy and depth are imparted to the ware, and some substance is given to the object. It is in this way that the magnificent blues of the Sèvres ware, certain browns, black, and a few other shades are produced.

The color may be either mixed with the paste or else applied to the object when it is shaped, before it is glazed or even mixed at all with the covering. Equally as well, may it be applied on porcelain already fired, and then fired again at the "strong heat." It is chiefly by this latter method that we produce our blues at Sèvres.

Here is an article of white porcelain. We will paint it with a mixture of cobalt oxide and glaze, and in this condition it will again go through the "strong firing," ultimately appearing with the magnificent colors with which you are familiar.

Some of the most brilliant results from ware decorated in the "strong firing" are obtained by what is known as the method of application. Long ago known to the Chinese, it has advanced by successive improvements until it has reached its present state of perfection. The researches of MM. Discoy and Talmours (1839), the tests of M. Regnier, at Sèvres (1840), those of M. Halot, at Montreuil-sous-Bois (1843), the observations of M. Riocneux, and finally, the labors of M. Fischbag, of Sèvres (1849), have each in their turn prepared the way. The first trials of the process at present in use appeared to have been performed at Sèvres by my distinguished predecessor, M. Louis Robert. This method of application consists of painting with the brush, either on the baked or else on the biscuit ware, with the proper slip; by successive applications it is possible to produce quite a thickness; then, by proper cutting away, the artist is able to give a beautiful finish and add considerable value to the object which he is decorating. Then the article is baked, glazed, and fired at a high heat.

When the slip has been applied to an object with a tinted body, by transparency most charming effects are obtained which make the porcelain seem to resemble cameos.

If coloring oxides are added to this slip a real painting will be obtained, by the "strong firing," which sometimes is very effective.

Unfortunately we are obliged to admit that, in the decoration by the "strong firing," in consequence of the excessively high heat required, the number of colors that can be obtained is very limited. However, this is not so when the decoration is fired by the heat in the muffle; in this method the painting is always made on the baked porcelain, and so consequently on the enamel, and then heated at a temperature comparatively low. The glaze cannot melt as is the case in "strong firing." It is necessary, in order to make the colors or the metals, such as gold, platinum, etc., adhere, to use an intermediate compound, which is called the flux. As a general thing, a sicilate or a silico-borate of lead is used (for the metals the bismuth subnitrate is preferred); by the elevation of the temperature these fluxes melt, and, attacking the glaze, combine with it, and, at the same time, by this reaction, produce the adherence of the colors. According to the nature of the fluxes and of the colors, the ware must be heated to a higher or a lower degree, and as certain colors are much more sensitive than others, it is frequently necessary to bake the porcelain at several successive and different temperatures.

The firing of colors in muffles requires great experience, and here again the need is felt for some instrument of precision, for no other means of determining the temperature existing in the muffles is possible than by observing on the test plates of porcelain the changes in color which certain very sensitive preparations undergo according to the differences in temperature. We have attempted to produce here, in this muffle, heated by gas, a firing of colors; in a moment you will be able to judge for yourself how well we have succeeded.

The palette at Sèvres is absolutely complete; by its use it is possible to reproduce, in the most magnificent manner, the *chefs d'œuvre* of the greatest painters, and, since M. Francois Richard has arranged what is called the palette of "half strong firing," muffle colors of a remarkable brilliancy are obtained.

Notwithstanding the beauty of our colors, obtained in the "strong firing," and the richness of our palette of painting, in the decoration of French hard porcelain there is still much to be desired. The colors obtained in the "strong firing" are too few in number and too delicate to allow any very great variety of effects; as to the muffle colors, although they are very rich in appearance, still they have one characteristic defect: they are opaque, they cover the porcelain, and hide all the qualities of this valuable material. You will better understand my idea by comparing these three objects: a painted porcelain vase, a decorated object in faience, and, finally, a piece of Chinese porcelain.

While, on the first, the colors are so opaque that it is impossible to decide whether they cover porcelain or are on some other substance, in the remaining two cases the objects are entirely transparent, and glisten like precious stones. It is because in these two cases the glaze is not made with opaque metallic oxides, but with enamels, that is to say, glasses, colored crystals.

The discovery of these processes for decorating has occupied the attention of ceramists for a long while, and I should indeed be neglectful of my duties if I failed on this occasion to render public homage for the remarkable researches which M. Salretat, formerly head of the chemical portion of the factory, has recently published, conjointly with M. Ebelmann, on this subject. He was able, in the course of his investigations, to lay the foundations of a new method of manufacture, which unfortunately circumstances have thus far prevented his establishing in an industrial way.

The factory at Sèvres is to-day in possession of these new means of decoration, and I only regret that at present it will be impossible for me to describe this new discovery, in which I am personally so much interested. I am desirous of saying a few words further in this connection for the purpose of expressing the great pleasure that I take in thanking my friend and co-laborer, M. Vogt, the present head of the chemical department at Sèvres, for the important part which he has taken in these investigations. Equally as well, I am indebted to my assistant, M. Giraud, whose intelligent help has been of the greatest service to me. I attach a positive importance to these new processes. I hope by their aid to be able to replace painting, properly so called, by a live and brilliant decoration, fully as fine as that of faience, which it will surpass by the value and delicateness of the material itself.

I am sure that the proverbial skill of the eminent artists at Sèvres will lead them to take an important part, and that by the application of their talents to the investigation of new decorative effects, they will ultimately succeed in producing not mere commonplace copies of Oriental wares, but rather a variety which will be distinctively French, and which will elevate porcelain once more to the rank which the artistic varieties of faience seemed about to take from it.

I have finished, ladies and gentlemen, this already too long lecture, but still I cannot cease from speaking without saying a word with regard to the position which, in my mind, the establishment whose name has been so frequently on my lips this evening, and whose director I have the honor to be, should occupy.

Under a monarchical form of government the factory at Sèvres was sustained by the civil list. It depended entirely upon the sovereign, at whose pleasure its products and processes were distributed.

The savants who have directed the works at Sèvres have always understood that they should advance, to the best of their power, this privileged industry of royal liberality.

This duty is to-day imposed upon us with an increased gravity, for the factory has become a national establishment, sustained by the country itself.

I think, therefore, that it should become a school of ceramics, and it should completely lose its character as a factory. Its duties should be the discovery of new processes, the production of new forms, the originating of new methods for decorating. It should educate artisans and artists, who should be masters of their art. It should—nay, further, it is its absolute duty—to circulate among the French industries the results of its investigations.

I am assured that if it was so conducted the factory at Sèvres would be of the greatest value to our national industry, and its achievements reflect most gloriously upon our France and our Republic.—*La Revue Scientifique*, 29, 233.

M. B.

RUSSET LEATHER.

REPORT ON THE MANUFACTURE OF RUSSET LEATHER AND ITS ADAPTABILITY FOR THE MILITARY SERVICE.

By CAPT. D. A. LYLE, Ordnance Department.

THE question having arisen as to the desirability of using russet leather for artillery harness, the writer was directed to examine into and make a report upon the subject. For this purpose he selected two typical fair-leather tanneries—one using hemlock, and the other oak bark, whose products were of acknowledged excellence.

For hemlock tannage, the tannery of "The Cappon & Bertsch Leather Company," of Grand Rapids, Mich., was selected. The tannery of Mr. Charles G. Smith, of Urbana, Ohio, was chosen to represent the oak tannage. Both tanneries make specialties of fair or "russet" leather.

For convenience of comparison the operations, etc., relating to the two tannages are described in parallel columns, headed, respectively, "Hemlock" and "Oak."

Explanations applicable to both tannages are made continuous across the page without regard to the columns.

"RUSSET" HARNESS LEATHER.

HEMLOCK.	OAK.
Hides.—The hides used for "russet" leather are green and salted Michigan skins. Green hides make a smoother, more uniform leather. They are carefully selected and classified. The packs are made as uniform in thickness and weight as possible.	*Hides.*—Green, same as for hemlock russet. Great care taken in selection to secure uniformity in size, quality, thickness, weight, and freedom from scratches, cuts, brands, holes, etc.
The heaviest hides are put into sole leather.	In the Eastern States green, salted, and South American dry hides are used by both hemlock and oak tanners.

Soaking.—The usual practice is to throw the classified packs into the "soaks" or vats, filled with soft water, for a day or two, or long enough to remove all the blood, salt, and other impurities; and then to throw them into the lime vats, paying no attention to working on the flesh until the hides come out of the lime and are put upon the beam.

This method, though sanctioned by long usage, should be discouraged, and the hides should be "fleshed" before going into the lime vats. On coming from the "soaks" the hides should be put on the beam, and the meat left on the hide in skinning "worked off," not "cut off." The latter process demands skilled labor to avoid injuring the skin and increases the cost of working—a result not consistent with true economy. But unskilled labor may be advantageously employed in a thorough *working off* of the attached meat, and still (1) break the *nerve* of the hide and (2) remove all obstructions to the uniform liming of the hides.

Where meat or grease is left upon the flesh the action of the lime is prevented, and all subsequent operations fail to produce a leather of uniform quality throughout.

A good many harness-leather tanners now remove the meat before liming, but the practice is far from universal. So far as is known to the writer, no mechanical contrivance has been devised to perform satisfactorily the unpleasant labor of "fleshing." Tanners still have to depend upon laborious manual "working." The French and German beam-knives or fleshers introduced latterly into this country have been of great advantage. The flexibility of these knives and the ease with which they accommodate themselves to the form of the convex beams readily recommend them to the enterprising tanner.

HEMLOCK.

Splitting.—The hides are split down the back in the beam-house before liming.

Trimming.—This is done in the beam-house. For harness leather especially, the sides must be carefully trimmed, or the buyer purchases at a high price a lot of useless offal fit only for upper-leather workers.

Liming. — After soaking, the sides are placed in the lime vats and left for five days. The liming process loosens the hair, removes the grease, and distends the fiber of the skin.

1st working —This operation is depilatory in its action, removing the hair and dirt from the grain side.

Fleshing or 2d working.—This is the removal of all meat adherent to the flesh side, as well as the excess of lime and dirt upon that side.

Milling or wheeling.—After fleshing, the hides are put in a rotating mill with a flow of warm water turned on, where they remain 15 minutes. This removes or knocks out the excess of lime and prepares the hide for the tan liquor.

Bating.—The *bate* is resorted to in order to further facilitate the separation of the lime from the skin and the ease with which the tanning principle is imbibed. Messrs. Cappon & Bertsch put their hides in a weak bate of hen manure, where they are left for three hours.

Some tanners bate still longer to git rid of the lime.

Bark. —White hemlock bark from Michigan used in tanning. The bark is coarsely pulverized in a bark mill and then thoroughly leached.

Black oak or quercitron bark gives a bright lemon-color to leather and forms a good finish for hemlock treated to imitate oak.

Best speed for bark mill is from 90 to 120 revolutions per minute.

OAK.

Splitting.—Mr. Smith does not split his hides into halves at this stage.

Trimming.—This is carefully done in the beam-house.

Liming—After soaking, the hides are limed *low—i. e.*, placed in a weak solution of lime for six days. During the liming the hides are cut along the back line and great care taken to keep the edges straight in subsequent operations.

Fleshing.—This is carefully done as for hemlock tanning.

Milling.—This is done after fleshing, to knock out the lime.

Bating.—Charles G. Smith and his superintendent, Mr. Kidder, claim that bates of hen manure, etc., for taking out lime are very irregular in their strength and action, and disapprove of their use. They remove the lime by the use of soft water bates. For russet leather, the sides are put in a wheel or mill running 50 revolutions per minute and furnished with a continuous supply of warm water. After two days of this treatment the hides are in good condition for handling. Mr. Jackson S. Shultz also recommends the removal of the lime by warm-water bates.

Bark.—The bark of the rock chestnut oak is used. It is ground in a bark mill and carefully leached. The bark is obtained from southern and central Ohio, and from the vicinity of Chattanooga, Tenn.

Sumac also used. It gives a lemon-color.

TANNING.

HEMLOCK.

Handlers.—The tan liquors first used are very weak, and then gradually increase in strength until the last layaway is reached, where the strength is greatest. The liquors vary in strength, according to the barkometer, from 7° in the first handler to 20° in the layaways. The barkometer is not much used and but little reliance is placed upon its indications. Most tanners judge of the strength of a liquor by its color and taste.

The sides are six weeks passing through the handlers. The plumping or distention of the fiber is done with the gallic acid of old but moderately clean liquors.

The action of this acid is to raise the skin and loosen the fiber so that it will readily absorb the tannin. The handling is done by hand, rockers not being used.

Layers or Layaways —Cappon and Bertsch use four layaways.

The method of packing is as follows: First, a little liquor is placed in the bottom of the vat, then a layer of dry bark is sprinkled over the bottom, upon which is spread a side, then another layer of bark and a second side, and so on, alternately, until the vat is filled.

When packed, the vats are filled with leached tan liquor until the sides are covered. The liquor in the last layer is the strongest used, being about 20° by the barkometer.

The sides remain in the

1st layer	15 days.
2d layer	20 to 25 days.
3d layer	40 days.
4th layer	40 to 50 days (average).

The *grain* side is placed *up* in the layaways to avoid scratching when removed with the hook.

Washing —This is done in a "slush" mill plentifully supplied with soft water and making about 13 revolutions per minute. The sides are milled from five to ten minutes.

Scouring.—The stock-stone, a stiff brush, and clean soft water, applied by hand, are used for scouring or scrubbing.

Drying.—The drying-loft is used for this purpose. It is generally heated by steam to a temperature of from 90° to 100° Fahr.

Bleaching.

1. Materials.—Flowers of sulphur.
   Alum.
   Sumac.

2. Number of bleaches.—Six. After scouring, the sides are passed through the six bleaches in succession. The *first* bleach has the weakest liquor. The others increase successively in strength to the sixth, which is the strongest.

3. Time.

1st bleach.—From 10 to 12 hours. The sides lie in this bleach over night, which is the longest time they are continuously exposed to the action of the bleaching solution.

2d bleach—Time, 12 hours.
3d bleach—Time, 15 hours.
4th bleach—Time, 20 hours.
5th bleach—Time, 24 hours.
6th bleach—Time, 24 hours.

In the last five bleaches the sides are handled constantly without being allowed to soak in the liquor. The handling is all done by hand.

Extreme cleanliness is very essential during these operations.

The exact proportions of the ingredients in the several bleaches were not given.

Stuffing.—This is done entirely by hand—using cod-oil and tallow. For "russet" leather use one-third (⅓) as much stuffing as for black finished leather. Wetting turns the leather *red.* The less grease used in stuffing the less the chance for stain or objectionable change of color. By putting plenty of grease on the leather and then dampening it, the color will change to a dark red.

Color.—Bleached as above described, the leather assumes a beautiful pinkish cream-color, which becomes lighter by drying. Rain or water will spot or stain it. The leather retains its color well in dry weather. The color is known as "a good, *live* color, light reddish in tinge." If much oil be worked in during the operation of stuffing and the leather afterward wet, it will change to a dark reddish color. The oil causes the color to be brought out.

[If great care be used in tanning and bleaching, and very little oil be used in stuffing, hemlock leather is said to be not more liable to *fade* than oak.]

Section. — Light reddish, "live" appearance; cuts with apparent firmness, and does not appear fibrous or stringy.

Grain.—If the leather is *properly* treated in handling, tanning, and finishing, there will be no cracking or breaking of the grain.

Poor leather.—Characteristics: cuts badly; the section has a dead, lusterless appearance; is woolly ("old batty" technically); the grain breaks when folded sharply.

Relative strength. — [Cappon.] Hemlock has about the same strength as oak, and with proper care in tanning, hemlock leather can be made as serviceable as oak. It cuts to better advantage and makes a plumper skin throughout (bellies, flanks, etc).

Solidity.—Good hemlock tannage makes a firm leather, but is not so solid as good oak. For stamped figures and ornamentation, hemlock is found to be less retentive than oak. This effect is probably due to the greater relative sponginess of the hemlock tannages.

Inspecting.—Note the feeling when cutting with a sharp knife. Examine carefully the character and color of the section. Handle the sides one by one, noting the impressions left upon the mind through the sense of touch. Examine the sides for brands, hook-marks, scratches on the grain, gashes, thin places, grub holes, and evidences of black rot. Fold the sides sharply to see if the grain cracks or breaks. See that the sides are properly trimmed and that they are of uniform thickness within reasonable limits, and that the back-line is approximately straight.

Condemnation.—Reject for bad section, harshness to the touch, hardness and want of pliability, over or under tanning, acid, raw-hide streaks, serious injury to flesh or grain, improper trimming, emptiness, and flimsiness of shoulders and flanks.

Storage.—Messrs. Cappon & Bertsch say that leather will stand for two or three years without being affected injuriously, if placed in a cool, dry place—not too dry—but that it will dry a little from the evaporation of the moisture and volatile elements in the oil used for stuffing.

After that period, leather will begin to deteriorate. Mr. Stout, of New Orleans, states (in a letter) that he has had Cappon & Bertsch's hemlock leather stored in an attic all summer (1881), with the thermometer ranging to 115° Fah., and that there was "no frying out." The amount of extractive matter in the bark will affect the quality of the leather. The amount of extractive matter in hemlock can be diminished by rossing the bark before leaching.

Stain.—The dampening of russet leather before stretching over saddle-trees discolors the surface somewhat, and has led to the practice of staining to restore the proper tint. Oak holds the stain better than hemlock.

Cleaning.—Castile soap and water are used. The result discolors the leather.

Cost.—The price of "russet" harness leather trimmed is from 3 to 5 cents higher than black leather.

If the inspection was what it should be, the cost would be greater than that above given.

Since very little oil or grease is used in finishing, it follows that in buying "russet" leather by the pound, less grease is bought than in any other class of leather.

Which leather, black or russet, would you recommend for harness?

Answer.—Black. Why?

It looks better after use and will wear better, because the tallow used in stuffing fills ("feeds the leather") all the pores of the sides, rendering them impervious to water, thus preventing decay. Rus-

OAK.

Handlers.—The best russet harness and saddlery leather pass through 20 handlers in succession and occupy three months in the process. The sides are handled *every day* with the utmost care, passing from the weakest liquors to the strongest.

The sides are suspended by their edges and the manipulation is all done by hand.

For russet leather the vats must be kept very clean. Filthy liquors cannot be used upon this class of leather without injuring the color.

Layers.—The same method of packing is employed in this case. The strongest liquor is put in the last layer. Two layers only are used; the hides remaining 30 days in each.

The vats require to be kept very clean. One hundred and fifty sides are put in a vat.

Mr. Smith places his sides with the *grain down* to protect them from being injured by the settling of coloring matter from the bark. The sides are taken out by hand in order to preserve the grain from hook marks.

Great care is taken to avoid stains on the grain in both tannages, especially the hemlock.

Washing.—The "mill" with soft water is employed for this purpose.

Scouring.—Is done by hand and machine, with either the stock-stone or stoning-jack, stiff brushes, and soft water used for cleansing purposes.

Drying.—Is done in the open air or by the assistance of steam for heating the air. It is best to dry *fair* leather without the use of steam.

Bleaching.

1. Materials. — Sugar of lead. Foreign sumac.

2. Number of bleaches.—Two or three, according to the quality of the liquors. The sides, 300 per day, are dipped successively in the liquor, and never leave the hand of the workman while in the vat; nor are they allowed to lie in the bleaches.

The sumac bath is made by using two sacks of foreign sumac to 100 or 125 sides, with just enough water to cover the sides. The amount of sugar of lead employed was not given. Tanners are generally chary of giving the proportions of their baths and solutions.

It has been claimed that if American sumac be gathered earlier, it will be freed from its objectionable color. Mr. Kidder, of Urbana, Ohio, states that this is not true, and that it is not equal to the foreign sumac.

Stuffing.—Tallow and stearine (from hog's lard) is used for stuffing. The latter operation is performed by hand. Little or no oil or grease is used in finishing leather in hot weather. In cold weather a good deal of stuffing may be applied without affecting the color of the leather.

Color.—Properly bleached, the grain of oak leather presents a bright russet color, generally known as "flesh-color," with a whiter appearance than hemlock russet. It becomes a little lighter in color by drying.

This is especially noticeable when the leather is finished and rolled up on a damp day and then kept from exposure to the air. It will lose color.

Section.—This presents a "live" appearance, indicating firmness and solidity, with a bright, mottled, light-brown color.

Grain.—The same remarks will apply to oak leather, though it is less liable to crack than hemlock from careless tannage.

Poor leather.—Badly tanned leather is "old batty" in section and harsh to the touch.

Relative strength—[Kidder]. The oak-leather tanners claim that the tensile strength of their leather is greater than hemlock.

Solidity.—Hemlock leather has never been made to surpass the best oak in solidity. For fancy russet saddle leathers it has been found that oak retains the stamped figures longer, and the definition of the impression better, than any other leather. This is due to its superior solidity and body.

Inspecting.—See that the grain is not too heavy, or it will be liable to crack. Examine the section along the edges of the back-line, the bellies, and flanks; note the color and characteristics of the section and fiber, which should be good. See if the leather will tear easily, which indicates rottenness. Test the pliability by handling all over. The sides should be firm and solid, of uniform thickness and weight. Examine for indications of high liming, excess of acid, and imperfect or not uniform tannage. High liming softens the leather, but is injurious to strength and wear; while strong bates ruin it. Look out for streaks of raw hide in the middle line of section.

Condemnation.—Throw aside for bad section, short tannage, raw-hide appearance, acid streak, and if too full of nerve or grain. Reject for too thick grain, for breaking or cracking on close folding, also for harshness and want of pliability.

The shoulders, flanks, and bellies should be plump and well tanned to cut to advantage.

Storage.—Messrs. C.G. Smith & Kidder state that good leather rolled, papered, sacked, and stored out of the wet in a cool, dry place—not too dry—will "stand five years without deteriorating." It should be kept from currents of air—especially fair leather. Heat evaporates the oil from the leather. Greasy russet leather should not be stored. Badly tanned leather is "old batty," and acid leather begins to deteriorate from the day it is stored; it "dies out," becoming more brittle and rotten from day to day.

Stain.—In oak tannage the use of black-oak bark (quercitron) in the last layer gives a beautiful lemon color or stain. This bark is used for making imitation oak or Union leather out of hemlock. Spanish saffron makes the best stain for russet saddles.

Cleaning.—Same as for hemlock. . Mr. Kidder suggests the "use of rock or kerosene oil for harness, and a white mineral oil for russet harness." He thinks it would be preferable to any other oil for dressing leather after washing, though he has not had much experience in its use.

He says mineral oil "is not half as *hot* as fish oil," and that it will not rot the leather so quickly. He also says that "fish oil and tallow gum too much and make the harness disagreeable to handle." "Castor oil goes right through the hide, and is too gummy and penetrating."

Cost.—There are not so many operations required in the manufacture of russet leather, but the greater care and skill necessary make the cost about the same as black. The defects being more apparent the loss from condemnation will be greater, and consequently the price must be higher to compensate for this loss. If russet leather should be adopted it would be policy to use only the best quality. Hence the necessity of having an inspector who thoroughly understands the processes of tanning, bleaching, and finishing, upon which its excellence depends.

Which leather, black or russet, would you recommend for harness?

Answer.—Black. Why?

To say nothing about the discoloration which would almost immediately follow use, russet leather is more permeable to moisture than black, from the fact that so little oil or tallow is used in

set leather having far less oil or tallow used in stuffing is very soft, pliable, and cleanly to handle, but will become discolored by sweating, rain, or by moist air.

"Russet leather makes handsome harness, but must be used only in dry weather to retain its color."—Bertsch.

Example.—A handsome set of harness came under the writer's notice this summer, that bears upon the point in question. It was made of hemlock russet, by Sargent, of Boston, and contained a very good quality of leather, but not as good as samples inspected in the warehouse of Cappon & Bertsch at Grand Rapids, Michigan. This set of harness was bought in June (1881); used for light driving in dry weather; taken to the sea shore early in August, where it was used in the moist air of such resorts until about October 5; having been exposed to *one* light shower of rain. The beautiful color had changed to a murky red on the saddle and backstrap, while the breeching and traces were tinged, in addition, with a shade of grayish brown. Taken as a whole, the harness struck the observer as being dirty but not disagreeably so.

It is a custom among buyers of russet leather harnesses to use them until faded or stained, and then to have them stained black like ordinary harness.

finishing. Consequently it would begin to deteriorate earlier and more rapidly. The opportunities for deception in the manufacture of black harness leather are, however, much greater than in russet. The black staining covers minor imperfections, and the leather being filled with tallow and oil, many defects are concealed which would be plainly apparent in russet leather. Consequently the buyer stands less chance of being deceived in russet leather than in black, provided the bleaching be honest.

There is so much grease in black leather, and it is so easy to cover its defects, that manufacturers generally prefer to make it instead of russet leather. The former can be made to deceive the best inspectors.

Remarks.—Mr. Smith, of Urbana, Ohio, makes fair leather for fine saddles, bridles, lines, and occasionally for harness, though he prefers not to make the latter since his reputation has become established. He does not manipulate his leather to produce the maximum of weight, but to secure the best quality of leather. His prices are high, but he deals only with large firms of manufacturers, who take his whole product, and who know what constitutes excellent leather, and find it economical to buy his leather, though at a higher price.

The writer being somewhat familiar with the operations of tanning and currying, carefully inspected the tannery of "The Cappon & Bertsch Leather Company," at Holland, Michigan, 25 miles from Grand Rapids, under the guidance of Captain Cappon. He also inspected that of Mr. Charles G. Smith, at Urbana, Ohio, in company with Mr. Kidder, his skillful superintendent.

Both establishments are models of cleanliness and plainly indicate the care that must be taken in the manufacture of russet leather. What most impressed the observer was the manifest honesty in the manipulation both in the tannage and in the finishing operations. Much of Mr. Cappon's hemlock leather is doubtless sold as oak leather after it leaves his hands. He has the reputation of making the best hemlock russet leather in the United States.

As has been seen above, neither of these firms would recommend the use of russet leather for harness which is to be exposed in service.

To obtain still further light upon this subject the writer visited and consulted Mr. F. K. Condict, of F. K. Condict & Co., of Newark, N. J., large manufacturers of saddlery and harness; Mr. George Allen, of Newark, N. J., currier and finisher of fine russet leathers; Mr. Jackson S. Shultz, Mr. George H. Stout, of New York, and other dealers in leather.

Not one of these gentlemen would recommend russet leather for serviceability in the field except Mr. Shultz, and he only on *one* condition: "that the question of *color* be overlooked *entirely*, and the leather stuffed with tallow and cod oil the same as any other harness leather." Mr. Shultz prefers neat's foot oil to cod oil, but claims, and with reason, that it is easier to procure cod oil unadulterated than neat's foot, owing to the high price of the latter.

The writer is under great obligations to Captain Cappon, of Holland, and Captain Bertsch, of Grand Rapids, Mich.; to Messrs. Smith & Kidder, of Urbana, Ohio; and to the several gentlemen above mentioned for valuable information and for the many kind courtesies extended to him.

BLEACHING.

In California "skirting" and other light-colored or russet leathers are handled in warm sumac solutions immediately after coming out of the layers. After drying, the leather is treated superficially with a saturated solution of oxalic acid to which a little sulphuric acid is added to give it the desired color. The sides are next set upon a table with a very little oil, dried slowly in a dark place, and, finally, finished by rubbing with a cloth. Skirting (used for saddles, etc.) is a heavy leather; but any desired thickness may be obtained by splitting before passing through the later operations.

From the above it will be seen that, although tanned with oak bark, the color is not considered satisfactory, and bleaching is resorted to in order to procure the requisite tint.

In the Eastern and Middle States fair-leather manufacturers use baths of sugar of lead and of sulphuric acid, into which the hemlock tanned leather is alternately dipped until the wished for effect is produced.

But, though the leather is beautiful at first, upon exposure to the light and air for a considerable time it turns a "murky brown" color, which is objectionable. These baths are very injurious to the leather. Probably the only honest bleaching process is the sumac bath. This bath involves an extra expense of from five to seven cents per side.

The sumac liquor contains a vegetable acid which acts favorably upon the sides, removing the coloring matter, softening the grain, and rendering the exterior whiter and clearer. Hemlock leather thus bleached will retain its improved color for a considerable time.

Mineral acids should never be used for bleaching purposes.

In England and on the Continent, valonia is extensively used for tanning. Leather tanned with valonia is said to be harder and less permeable to water than oak tanned.

Sicily sumac is also extensively used, but probably more for the lighter leathers.

The scarcity of oak bark, and the more or less general use of valonia may account for the use of light colored or "russet" leathers in some foreign armies. In this country valonia is too expensive for tanners' use, as it has to be imported.

It requires a little more labor to stain harness leather *black* than to finish it light colored; but the extra care taken to exclude the light and currents of air when drying the latter, fully counterbalances any saving due to hand labor upon the former.

COST.

There would be little difference in the cost of russet and black leather, provided valonia or foreign sumac be not used. If the imported articles were used the cost would necessarily be greater.

TENSILE STRENGTH.

If untouched by mineral acids for bleaching purposes, the strength of the two kinds—hemlock and oak—would not differ. In this country it would be almost impossible to obtain russet leather that had not been subjected to more or less of acid treatment, which would impair its quality and strength.

DURABILITY.

Russet leather, not being protected on the grain by having the pores filled with unctuous blacking, would be more permeable to water, and everything else being equal, would not be likely to be so durable as black.

EFFECT OF STORAGE.

Most leather begins to deteriorate as soon as stored. Pure bark tannages with excellent care will probably stand storing from two to five years without marked deterioration. Mr. Shultz states that with pure tannage and perfect treatment during and after tanning, leather should remain good for fifteen or twenty years. He also says that good hemlock leather will stand storage from five to ten years if it be not stuffed with oil or grease, but that if made up into harness it will begin to deteriorate within periods varying from six months to one or two years.

EASE OF CLEANING.

Russet leather is more difficult to clean than black; washing alone with either water, or water and castile soap would impair the color, and if oiled, care would have to be taken that only the best oil be used. The oil should be clarified to avoid discoloration from this source.

RESTORING LEATHER.

Mr. Shultz claims that harness that has been stored until the leather begins to get brittle and crack, may be measurably restored to pliability by first dipping it in a vessel containing a mixture of one-half tallow and one-half cod or neat's foot oil heated to a temperature of 100° Fahr., and then in hot water (about 110° Fahr.). Let the harness remain about two minutes in each, and then hang up to dry.

The hot water drives in the oil, softening the leather, and leaving the surface free from the gumminess usually attendant upon oiling.

GENERAL APPEARANCE.

When new, russet leather equipments would be striking, but probably would not accord well with the plainness of our army uniforms. They would be rather conspicuous in the field and easily discolored, presenting an appearance the reverse of military spruceness. When repairs are made the new parts would form a striking contrast to the older ones—since there is no blacking in this case to render them uniform in color.

When new, russet leather would furnish handsome horse equipments, but the stains incident upon the sweating of the animal, rain, and the spattering of mud, could not be easily effaced.

Any endeavors to clean such harness would probably result in leaving areas of a murky reddish brown color.

HEMLOCK OR OAK.

The question of whether the army should be supplied with oak or hemlock tanned leather has been agitated from time to time during and since the war.

The Government still clings to oak, and nearly all its specifications call for oak tanned leather, notwithstanding the fact that the greater part of the leather used during the war was bad hemlock, rendered more worthless by attempts to make it imitate oak leather. A large portion of the leather sold to the Government since the war has doubtless been hemlock.

Of late years the methods of tanning with hemlock bark have improved with astonishing rapidity, and now it is the chief material used. During the past few years hemlock leather has risen greatly in the estimation of consumers. There can be no doubt that as now made it is a valuable product.

Let the specifications call for "bark-tanned" leather—either oak or hemlock—and the result will be that base imitations of oak will cease and the Government will receive a better quality of leather.

There are few army officers who *know* anything about leather, and it is not possible for army inspectors, no matter how great their egotism may be, to detect imitations that defy the skill of expert tanners themselves.

The writer, in a report made in 1877, urged that a mixed commission of army officers, civil or mechanical engineers, and practical tanners, be appointed by the Government to make a scientific investigation into the relative merits of the several tannages, and to determine definitely, if possible, for what purposes the different tannages could be advantageously used. These points could be settled in time of peace, when there is no pressing need for large supplies.

CONTRACTS.

The purchase of leather by contracts given to the lowest bidder usually results in securing a stock at a price in excess of its real value and less than that for which good leather can be bought. A change in the specifications as above indicated would doubtless better the quality somewhat by excluding the grosser imitations.

Could the purchasing agent always be depended upon for honesty, it would be more economical for the Government to buy its supplies direct from the various manufacturers whose reputation for sterling integrity was above suspicion.

The Government would then pay a fair price for a good article. But experience has proved that human frailty cannot withstand temptation, and the contract system had to be devised to prevent fraud and gross favoritism as much as possible.

The great defect of the contract system is that, in a measure, it legalizes fraud by rendering gross deceptions possible.

Tanners and other manufacturers of the highest standing have informed the writer that they never thought of putting in bids for Government supplies, as they could not honestly fill the contract at the prices awarded. However defective the contract system may be, it is the only safeguard and protection that the Government official has for his honor. There is probably no official of integrity who would not rather allow the Government to get a poor article by contract than to risk being placed under the imputation of having been bribed, should he purchase a good article at a fair price from honorable dealers.

The following compound is used for oiling the harness and artillery saddles in store at the National Armory, and appears to be very satisfactory in preventing mould, preserving pliability, and freedom from stickiness and rubbing off.

HARNESS DRESSING.

[Ingredients for two gallons of the compound.]

1 gallon of neat's foot oil.
2 pounds of bayberry tallow.
2 pounds of beeswax.
2 pounds of beef tallow.

Put the above in a pan over a moderate fire and let them remain one hour until thoroughly dissolved; then add

Two quarts of castor oil and stir well until the mass comes to a boil so that the ingredients may become thoroughly mixed; after which add

One ounce of lampblack and stir well for ten minutes; then strain the liquid while hot through a cotton cloth to remove sediment of beeswax, tallow, and lampblack, and put aside to cool.

Apply this mixture to saddles and harness with a woolen cloth and leave until the next day, when they should be wiped off with a woolen cloth to remove the superfluous lampblack.

FOR "RUSSET" OR FAIR LEATHER.

Use the same mixture without the lampblack.

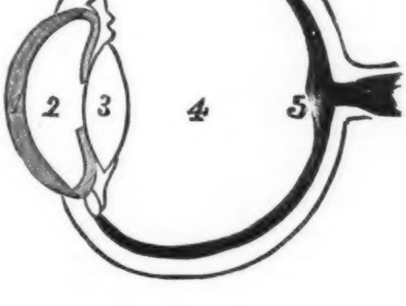
THE HUMAN EYE FROM A PHOTOGRAPHER'S POINT OF VIEW.

By D. G. THOMSON, M.D.

THERE are many points of interest to the photographer in a consideration of the structure of the eye and a study of the analogy it bears to the photographer's camera and lens. It is my present purpose to point out, in the hope of a possibility of our learning and assimilating to our profit some points by which the mechanical agencies employed by photographers in throwing images on a ground-glass screen are effected by the organ of vision in the sense of sight. We must bear in mind that, although the tissues of the eye are not brass, mahogany, nor glass, yet, so far as the projection of an image on the retina—which is the equivalent of the ground-glass screen—is concerned, the process is easily explained on a mechanical basis; and it is only as far on in the process as the projection of an image on the retina that I shall deal with. The more abstract and psychological portion of the process of vision—namely, the reception and conception of visual impressions on the retina by the brain—I do not enter into, as, of course, here the analogy between the photographer's camera and lens and the human eye ends.

Essentially, then, the eye consists of a camera obscura, of a lens, of diaphragms, of a screen or sensitive plate, with accurate arrangements for preventing spherical aberration and chromatism, for insuring perfect and rapid focusing and perfect definition all over the field; and I should not forget to mention the mechanical means by which the camera can be inclined at any angle and directed to any object, with which the most perfect studio stand cannot compare for a moment, either for universal motion or steadiness and rapid action. The stand for the human camera and lens is the head, which might be likened to the coarse adjustment of a telescope; for, the eye being fixed, it follows the direction of the movement of the head, until roughly, so to speak, in range. Then a set of muscles or contractile bands, which have no analogue in the photographer's armamentarium, come into play, and direct the eyeball exactly toward the object looked at. Thus, there are no rising fronts or swing-backs in the human eye, as the axis of the eye can, by the stand above referred to, be directed in any upward, downward, or sideward direction, without any fear of distortion or falling in of straight lines on the screen or retina; for this screen is not flat, like the ground-glass screen, but concave or cup-shaped.

Before proceeding to examine and compare the human camera, lens, etc., with our artificial ones, let us arrive at a definite notion of the relation of parts in the eye. This will be readily seen from the following diagram:



Beginning at the reader's left of the diagram is, first, the cornea (1), which is a transparent projecting window, consisting of a perfectly transparent membrane, having practically parallel concavo-convex surfaces. Next is the anterior chamber (2), a small space containing a watery fluid, the aqueous humor, the use of which, among other things, is, no doubt, to introduce another medium of different refractive power from the lens and cornea, and so to diminish chromatic aberration. Next is the lens (3), the most important refractive structure of the eye. This is a single, although not a simple, lens of about an inch focus and half an inch in diameter, double convex, more flat in front than behind. The structure of the lens is very complex, but it consists essentially of fibers united, side by side, to each other, and arranged together in numerous layers, which are so placed upon one another that, when hardened in spirit, the lens splits into three portions in the form of

sectors, each of which consists of superimposed concentric laminæ. The lens increases in density, and therefore in power of refraction, from without inward, the central part being the most dense. The density of the lens increases with age. It is comparatively soft in infancy, but very firm in advanced life; it is also more spherical at an early period of life than in old age. This lens is held in position by being attached, at its outer border or periphery, by contractile bands, to the sclerotic and other framework parts of the eye. Next in order is the large chamber (4) containing the vitreous humor—a watery, pellucid fluid which, by its tension, maintains the globular form of the eyeball; it also exercises some share in refracting the rays of light to the retina, and keeps the surface of the retina at a proper distance from the lens. Next is the retina (5)—shown in the diagram by the broad black line—which is the analogue of the ground-glass screen in the photographer's camera, receiving the light impressions thrown on it by the lens. Rays of light, then, pierce first the cornea, then the aqueous humor, then impinge on the lens, where they are collected, and, traversing the vitreous humor, are thrown on the retina or screen.

Now, the first thoughts that will suggest themselves to the photographic mind are—How are chromatic and spherical aberrations in the eye got rid of, and how are the images focused on the retina so as to give well-defined pictures? For nothing has been said about combinations of lenses, diaphragms, nor adjusting screws, which are the means of effecting these arrangements in all mechanical optical apparatus.

In the organ of vision spherical aberration—and the regulation of the amount of light admitted—is prevented much in the same way as in the camera, viz., by a diaphragm. I say "*a* diaphragm," and not a set of diaphragms; for this is an elastic diaphragm, or stop, called the iris, which may contract to an opening the size of a pin's head or dilate to half an inch in diameter. This contraction and dilatation of the diaphragm is familiar to every one in the cat's eye, and can also be readily observed in the human eye under varying conditions of light; for the iris is automatic, and acts in a reflex manner according to the amount of light. The aperture of the diaphragm is what is popularly known as the "pupil." Why the aperture in the diaphragm or iris should be elliptical, and not circular, in the eyes of certain animals—*e. g.*, the cat—I fail to understand, and I cannot see any reason to recommend elliptical apertures in diaphragms for photographic use. The amount of light admitted through a lens is regulated either by a series of stops of different sizes, or, in the smaller lenses and where the stops have not very large apertures, by a rotating disk perforated with a graduated series of apertures. I understand that some authority on stops has suggested a diaphragm in which the aperture can be enlarged or lessened at will by a simple mechanical arrangement, which, although not generally used, will commend itself to photographers by its portability and convenience; for who has not often found, after arriving on the scene of photographic action, that he has left his stops at home, or at all events that one is missing, or that, having brought them, one has fallen down in the sand or copse and got lost? We cannot have an automatic stop like the iris but we might I think, imitate rudely its dilating and contracting properties with advantage.

Spherical aberration, then, in the eye is got rid of by the iris or diaphragm and by the concavity of the retina or focusing screen, which is not flat, like the ground glass of the photographer's camera, but has a curve parallel, or rather similar, to the posterior surface of the lens. Chromatic aberration, I need hardly say, is prevented in the portrait and view lenses by having combinations of lenses made of glass having different refracting indices. In the eye, however, there are several refracting media which the light penetrates on its way to the retina, so that it is not necessary to have different lenses, seeing that the vitreous humor (the lens), and its capsule (the aqueous humor), and the cornea are of varying density enough to correct the unequal refraction of the different constituent colors of white light to prevent chromatic aberration

In addition to this, however, we have seen that the lens is more dense in the center than at the periphery or at the surface, and that it is made of layers of varying density and shape, so that the lens *per se* is probably quite achromatic, independently of the media before and behind it The concave shape of the retina or screen admits of little or no distortion in the image which is met with in the camera picture; also, the field of vision is much larger, the lens being very wide angled and the curved screen admitting of good definition all over the field.

The interior of the camera is painted black, so as to absorb all stray and reflected light; this is also the case in the eye, for the interior of the eye and posterior surface of the iris are covered with a layer of cells filled with black pigment, and constituting the so-called "choroid coat," which absorbs all the light reflected from the retina and prevents it traversing the substance of the iris. In albinos vision is never very distinct, as this choroid coat is partially or totally absent, admitting of reflection and re-reflection of light, causing blurring of the image.

Having now briefly considered how spherical and chromatic aberration are got rid of in the eye, let us glance at the apparatus by which all we see is clearly focused on the retina; in other words, where are the adjusting screws, the racks and pinions, by which this is done by the photographer in focusing his image on the ground-glass screen? This process in the eye receives the name of "accommodation," and is really one of the most admirable of the many wonderful self acting processes going on continually in our different organs

As a general rule, I can see distinctly any object at a distance of ten inches from my eyes; but, by an effort of accommodation, I can see distinctly objects placed either much nearer or much farther away than ten inches. Now, to effect this I must have done one of two things—either I have moved the lens nearer or further from the retina, or I have altered the shape, and consequently refracting power, of my lens. The amount of either of these changes required in even the widest range of vision is extremely small; indeed, according to one calculation, a line would be the range of alterable distance between the lens and retina, supposing the lens to retain the same form. It is now almost universally believed that the immediate cause of the adaptation of the eye for objects at different distances is a varying shape of the lens, its front surface becoming more or less convex according to the distance of the object looked at—the nearer the object the more convex does the front surface of the lens become, and *vice versa*—the back surface having little or no share in the production of the required effect. That this is so is easily demonstrated by the following simple and interesting experiment, which may, I dare say, be familiar to many: Hold a lighted candle near some one's eye. Three images will be seen—one on the cornea, another on the anterior, and another on the posterior, surface of the lens. If now an effort of accommodation be made, the second image, or the one produced by the anterior surface of the lens, and which is a vertical image and the largest of the three, will alter in shape. When we focus for a near object the lens will become more convex, and the image of the candle will become smaller. This, then, proves that the lens alters its shape in accommodation or focusing, although there is nothing to disprove the possibility of the actual distance being diminished or increased between the crystalline lens and screen as well. When the lens has become opaque in the disease called "cataract," and has been removed by operation, no distinct images reach the retina unless an artificial lens be worn as an eyeglass; then, of course, accommodation power is lost, but vision may be fairly good.

It may be of interest to the photographer to know how this alteration of the shape of the lens is brought about, although it is somewhat difficult to explain, and is one of those processes which we can never hope to imitate until some one discovers glass of the consistence of India-rubber. The lens is contained in a capsule, which capsule is at its free border attached to the sclerotic coat of the eye, which is equivalent to the camera. This capsule is stretched tightly over the lens, and compresses it. Now a muscle, called the "ciliary muscle," is brought into play when we accommodate for near objects, and its action is to draw forward the sclerotic, thus loosening the tension of the lens capsule, and the lens by its inherent elasticity becomes more spherical, and the image is focused sharply on the retina. On diminution or cessation of the action of the ciliary muscle, the lens returns in a corresponding degree to its former shape by virtue of the elasticity of its suspensory ligament.

With regard to the inversion of the image on the ground-glass screen, it is needless to say that the same occurs on the retina; yet objects do not appear inverted to us. This has received various explanations, but it is probable that the correct one is this—that in the conception of the images received on the retina the mind is assisted by the other senses in forming correct ideas of their shape, size, and position. In fact, the senses of sight and touch are so closely correlated that from our earliest years we employ the two side by side; and thus, probably, in the mental pictures we form from the retinal images of the objects around us we intuitively or unconsciously reinvert these images.—*British Journal of Photography.*

ASTRONOMICAL PHOTOGRAPHY.

At a recent meeting of the New York Academy of Sciences, Prof. John K. Rees lectured upon "Some results of Photography as applied to Astronomy." The lecture was continually illustrated by diagrams, etc., thrown upon the screen with the lantern.

Prof. Rees first showed the method in which the photographs were taken, the plate being held by a shutter of peculiar arrangement screwed into the part previously occupied by the eyepiece of the telescope. He said that our late Dr. John W. Draper was the first one who had taken a photograph of the moon, etc., successfully. The great difficulty being in the fact that by the movement of the earth the image of the body passed over the plate and produced a blurred reproduction, especially when the exposure was from twenty minutes to half an hour. Dr. Draper compensated for this movement by moving the plate along by a complicated apparatus of extreme delicacy, and thus a perfect photo was taken for the first time. This one had a diameter of only one inch, but allowed to high magnification. The time of exposure was twenty minutes, and the image very clear and distinct.

The differences between and the two forms of telescopes were then shown, and the principles involved explained. The refracting or Newtonian telescopes were shown to be the more convenient to use in this work, as both the visual and actinic rays were projected to the same focus, and both reflected together upon the eye or plate exposed; while in the refractor the two sets of rays were bent toward different foci, and thus either the one or the other lost. The reflector at Paris, and the refractor in the United States Naval Observatory in Washington were shown and explained.

The accomplishments of Rutherfurd in this department were then brought forward, and the peculiar arrangements he used, to obtain such perfect results, were shown and explained. The views shown this evening were mostly his, and were apparently perfect in every respect. Three photographs of the moon were then shown, the first quarter, full moon, and last quarter, and the geographical points there shown explained. A hand sketch, Smith's map of the moon, was shown with its great exactness and distinctness; there is a great difference between sketches and photographs here apparent. Referring to the photos taken of the sun he said that the time of exposure was but one three-hundredths of a minute, and to secure this a shutter of a very peculiar construction was employed; it consisted of a rectangular plate, held to the inclosing frame, to the right, by a strong spring, and having in the center a round opening; this is set in a frame and the opening pulled past to the left of the sensitized plate, protected by the ground plate; it is held in this position by a twine. The ground plate is then removed, the flame of a candle suddenly brought in contact with the twine, the spring acts, and the opening flits over the plate, exposing it for the time to the sunlight evenly and thoroughly. By this apparatus excellent photos have been taken, and a series of them was shown, showing the movement of a group of spots across the face of the sun. Several others were shown, mostly of one spot, from a low magnifying power to a very high one, and also the peculiar mottled appearance of the sun. Then some hand sketches of this appearance, by several authors, one representing it in the form of willow leaves, the others as rice grains. The use of photography for recording the changes constantly occurring on the sun's surface was discussed, and their importance in showing any connections between them and the weather, crops, financial panics, etc., as is claimed by some.

He then showed a number of photos of total eclipses; of the last eclipse much was said, especially upon the immensely elongated corona and wings of light observed, showing the sun's atmosphere to have a height of at least 10,000,000 miles, according to the photos. The method of training the observers for quick, accurate, hand sketching was described, and the great personal aberrations shown in these cases. The transits were shown, and their objects and principles explained. He said that American observers had had the best success in obtaining the solar parallax at the last transit with the forty foot telescope employed, and also upon the transit to occur on December 9, 1882, which is to be perhaps best observed in New York city.

"Tannin."

THE USE OF COAL GAS FOR LIGHTING AND HEATING.

Professor Armstrong lately delivered a lecture on the above subject, at the London Institute, Finsbury Circus, E. C.

In opening the subject of the lecture, Professor Armstrong gave an experimental description of the properties and composition of air with special reference to illustrating that combustion was in all cases a union of the material which was burnt with atmospheric oxygen. Demonstrating by some well-chosen experiments how hydrogen and carbon invariably form water and carbonic acid as the products of their complete combustion, the lecturer showed the presence of these compounds in the combustion products of coal gas. Turning to the composition of the gas supplied by the principal London Gas Companies, Professor Armstrong pointed out that the chief constituents present burned with a non-luminous flame, and that the light-giving compounds formed less than 5 per cent. of the entire bulk; also, that a large amount of the illuminating value of coal gas was due to the presence of substances which in their normal condition were liquid or solid. While the luminous gases consist principally of ethylene (C_2H_4) and acetylene (C_2H_2), naphthaline ($C_{10}H_8$) and benzole (C_6H_6) were given as examples of the solid and liquid substances present in the form of vapor. It was shown by experiment that the non-luminous flame of hydrogen is rendered luminous by the mere admixture of a very small quantity of the vapor of either of the compounds named.

Turning to the theory of the luminosity of light-giving flames, Professor Armstrong stated that the explanation of the light [illegible]ing due to the intense ignition of minute particles of carbon was no doubt a true one; the great heat of the flame decomposing the richer hydrocarbons present in such a way that solid carbon particles were liberated, becoming subsequently heated to a sufficient degree to evolve light. At the same time it was pointed out that although this explanation was probably true for coal gas flames, it was not always necessary to have solid particles in a flame in order to obtain light, as exemplified by the fact that substances were known which could not possibly be presumed to give solid particles of any description during their combustion, although they afforded luminous flames. Pressure had also much influence on the question of the luminosity of flames, the ordinary non-luminous flame of carbonic oxide becoming luminous when burnt under a pressure of ten atmospheres.

With respect to the proper conditions for developing the best light from coal gas, Professor Armstrong remarked that the primary requisite was the regulation of the air supply. For luminous flames the air should be supplied at the exterior of the flame; while for heat effects it was supplied to the interior, as in the case of the well-known Bunsen burner, in which the flame was non-luminous, the reason being the direct and perfect combustion of the gases present without any liberation of solid carbon particles. Speaking of gas-burners, attention was directed to the fact that slit burners were almost entirely replacing the older forms of fishtail. The fishtail depended on producing a perfectly formed flame from the impingement of two separate jets striking each other at an angle, and any particle of dirt or rust interfering with the integrity of either jet also interfered with the proper development of the whole flame. In the ordinary slit burners, on the other hand, this is not so, there being a simple sheet of flame. The air supply to these flat-flame burners was pointed out by the lecturer to be dependent on the velocity with which the gas was made to issue from the burner; experiments being given to illustrate the effect of a gradually increasing pressure. Reference to a table showed that an excessive pressure, while it increased the gas consumption, decreased the amount of light owing to the induction of an excess of air. A gas-burner consuming 5 feet per hour, which gave a light of 9·95 candles at a pressure of 8-10ths of an inch, gave only 8·9 candles with a consumption of 8·4 feet of gas when the pressure was increased to 18-10ths; while at 2 inches pressure 8·9 feet per hour were consumed with a light of only 6·7 candles. The benefit to be derived from good gas regulators was then pointed out, with special reference to the latest form of Sugg's; particular attention being directed to the fact that where regulators were in use the varying pressure at which the gas was supplied was automatically controlled, and an equable light always insured under economical conditions.

Among other gas-burners exhibited was a burner consisting of two separate flat flames, impinging on to each other so as to form a single flame, and it was shown that the light of the two flames combined was considerably greater than that of the two flames separately. This effect was attributed in great part to the heating of that portion of the air supply which entered between the two flames. Kidd's albo-carbon light was then exhibited; the lecturer pointed out as a special feature of this apparatus that the carbureting material (naphthaline) was a solid, and that its vaporization by the gas was regular, and obtained by very simple means, whereas in the case of the carbureters formerly in use, where a volatile liquid was employed, the apparatus required was more complicated, and the action more or less irregular. Sugg's 200-candle burner with three concentric rings of flame was next shown, attention being directed to the whiteness of the light, and to the fact that a light equal to 4 candles per cubic foot was obtained, while with the ordinary type of small burners the light seldom exceeded 3 candles per cubic foot. The result with the Sugg burner was attributed to the better regulation of the air supply, the proportions of gas and air being such that the flame is raised to its maximum temperature, and thus affords a whiter and better light.

Turning to the Siemens burner, of which Professor Armstrong stated his belief that it would do great things for gas, the details of its construction and the principles of its action were explained. Speaking of the benefit to be derived from heating the air supply, it was maintained that in 1854, Professor Frankland contrived a burner somewhat on the principle of the Siemens. The burner was an ordinary Argand, but was supplied, in addition to the ordinary chimney, with a second chimney which surrounded the first one, and the shape of which was conical. Both chimneys rested on a flat circular plate of brass, and the arrangement was such that the air supply entered between the two chimneys, thus becoming intensely heated before it reached the gas flame. This arrangement effected a very marked improvement in the development of light, the burner giving with an ordinary chimney a light of 14 candles, while with the second chimney in position, and the consequent heating of the air supply, the illuminating power rose to 21·7 candles with the same consumption of gas. This burner, however, never came into general use.

While speaking of the effect for improving the light of

heating the gas and air supplied to a burner, attention was directed to the fact that both the Metropolitan gas referees in their report on gas burners, and the special committee appointed by the British Association to investigate the general question of the best means for developing the light from coal gas, expressed their belief that heating the gas was not attended with any advantage in the way of increased light. The recent improvements in gas-burners entirely contradict this belief, the Siemens burner giving no less than six candles per cubic foot of gas burnt.

The lecturer concluded by expressing his belief that if the public fully recognized that of the bulk of the gas supplied for their use, barely 5 per cent. consisted of light-giving compounds, they would prefer to burn paraffin lamps sooner than continue to use a source of light which damaged their books and furniture by its combustion products.

ON THE ACTIVE CONDITION OF OXYGEN.

In an interesting article, Moritz Traube discusses the various opinions that have been advanced with reference to the remarkable change of oxygen from the ordinary passive condition to the active condition. He then, further, describes a number of experiments which he undertook with the object of determining whether, when hydrogen dioxide is formed in consequence of slow oxidation of metals in the presence of water and air, its formation is due to oxidation of water, as is commonly held, or to reduction of oxygen. He shows that in most cases the formation cannot be ascribed to an oxidation process; for experiment proves that, if substances which are easily oxidized are present, they are not oxidized under the circumstances which give rise to the formation of hydrogen dioxide. Thus, when zinc is shaken with water and air, hydrogen dioxide is formed; but if indigo-sulphuric acid, an easily oxidizable substance, is present in the water, it is not oxidized. Hence it is not probable that the water, which in general resists the action of oxidizing agents, is oxidized under these conditions. It is also shown that potassium nitrate is readily reduced when brought together with zinc, water, and air, hydrogen dioxide being formed at the same time. The action accompanying the formation of the dioxide is reduction; and, in all probability, the dioxide itself is formed by the addition of hydrogen directly to oxygen, and not by the addition of oxygen to water.

The remarks introductory to the paper are interesting and are here given: "Oxygen at the ordinary temperature is characterized by great passivity. While at high temperatures it burns up all organic substances without exception, at ordinary temperature it affects but very few of them. In the animal body, on the other hand, it becomes active, and now has the power of effecting oxidations at temperatures below 40° which it can otherwise effect only at red heat. Here it burns up all carbohydrates, fats, and albuminoids, forming carbon dioxide and water, the alkali salts of the plant acids forming alkali carbonates. Regarded from this standpoint, the adult animal, which neither loses nor gains in weight, plays the part of a catalytic body, which, without suffering material change in composition, causes at low temperatures, by means of the oxygen of the air, the almost complete combustion of enormous quantities of food. But not only animal organisms have the power of rendering oxygen active; the same property, though to a much less extent, is possessed by plants, or, in general, by all organisms down to and including bacteria and fungi. There does not exist an organism which is indifferent toward oxygen, which, when brought in contact with this gas, will not take it up and be at least partly converted into carbon dioxide. Upon this power is based the most important act connected with the life process, the chemical part of respiration with which the effecting of the most important phenomena of life is intimately associated.

"It was formerly assumed, in accordance with Liebig's view, that respiration serves only the purpose of keeping up the temperature of the body and that the oxidation processes only take place in the blood. Even J. R. Meyer was of the opinion that respiration only produces heat which is transformed into motion in the muscles, and that the blood is the real hearth of the organic combustion processes. I first pointed out, with conclusive reasons, that the real hearth of the respiratory processes is, not the blood, but the tissues of the body, above all the muscles; that the oxygen taken up in the lungs is set free in the capillaries of the body, enters as dissolved gas into the tissues of the individual organs; and that in this way each individual organ breathes independently at the expense of the free oxygen. It is only in consequence of this breathing that the individual organs are enabled to grow, to perform their functions, to yield secretions, and to generate the different forces which characterize them, as, for example, the force of the muscle, nerve force, etc.

"Thus, not only do organisms as a whole have the power to make oxygen active, but each of their organs, indeed each individual cell; or rather they contain substances which have this power. Hence the problem of active oxygen is in the highest degree important, as well for physiology as for chemistry.

"Oxygen can also be made active by a few processes which take place without the organism. Thus, as is well known, it is affected in a high degree by platinum and phosphorus. In the presence of finely divided platinum it oxidizes energetically at the ordinary temperature hydrogen and alcohol, substances toward which it is usually indifferent. But, although the phenomena in inanimate nature are much more accessible to experimental investigation than the more complicated phenomena of life, a satisfactory theory of the process has not yet been framed on an experimental basis. A number of hypotheses regarding the process in inanimate nature as well as in the organisms have been advanced."

The views of De la Rive, Liebig, Schönbein, and Brodie are then given, and finally reference is made to the view of Hoppe-Seyler, according to which "hydrogen in the nascent state has the power to split the molecule of oxygen, uniting with one atom of the molecule and thus setting free the other as *active* oxygen possessed of highly energetic oxidizing power. According to the view of the same author the life process in the animal body resembles a case of decomposition accompanied by an evolution of hydrogen, and it is this nascent hydrogen which renders the oxygen taken up in respiration active."

He then speaks of a hypothesis advanced by himself in 1858. "According to this the oxygen is rendered active by *oxygen transferrers* (Sauerstoffüberträger). These are bodies which . . . have the power of giving up easily to other bodies the oxygen which they absorb and then again taking up oxygen immediately. This process may be followed readily when the oxygen transferrer is colored in oxidized condition and colorless when reduced.

"The ammoniacal solutions of copper salts, and indigo-carmine, are easily reduced by many bodies, as grape sugar, and then become colorless. If, however, they are in contact with oxygen, they take it up again and are changed back to their original condition, only to give it up to the sugar. This alternating reduction and oxidation continues until all the sugar is oxidized, while the oxygen transferrer itself (for example, the ammoniacal copper solution) appears unchanged at the end of the experiment. Thus small quantities of the transferrers can transform large quantities of bodies which of themselves cannot take up oxygen. . . . In the different parts of the paper which are to appear these various hypotheses will be discussed in full."—*Berichte der Deutsch. Chem. Gesell.* xv., 659.

GELATIN JELLY AS A DIALYZER.

By R. C. Woodcock, F.C.S., F.I.C.

Jelly prepared from gelatin has been employed by Dr. Dupré for the separation of artificial coloring matters in wines, but, so far as I am aware, its application to ordinary dialysis has never been carried out. Its use in toxicological chemistry may, however, demand some attention, as the following experiments will show:

A mixture was made of four different soups—thick and clear—about one and a half pints in all, together with boiled rice and macaroni; a little pepsin and pancreatin was added, the mixture acidulated with hydrochloric acid, and digested for some time at a temperature of about 90° F. One and a half ounces of concentrated hydrochloric acid was then run in, and the mass heated nearly to boiling, when it was allowed to cool and filtered. To the filtrate 0·5 gr. of strychnine was added, and the whole diluted to 10,000 grs. 5 grs. of this mixture (=0·00025 gr. of strychnine) was diluted to 2,500 grs. with water, and a gelatin cube placed in the solution, in a beaker. The jelly was prepared by making a 6 per cent solution of gelatin in hot water, allowing it to set in a suitable vessel, and then cutting a cube about 1¼ inches. The solution was dialyzed for sixty hours; the cube had swollen somewhat, but was quite intact. The liquor was poured off, the cube well washed with distilled water, and heated in the beaker in a water-bath, and concentrated until a film of gelatin formed upon the surface of the liquid, when it was removed from the bath, cooled slightly, and strong alcohol added to about the same bulk as the liquid, a large proportion of the gelatin precipitated, and ether added until precipitation was complete. The ether and alcohol together amounted to about twice the volume of the concentrated gelatin solution. The mixture was well stirred, the gelatin adhered in a mass, so that the liquor poured off sufficiently clear without filtration. It was evaporated to dryness, and the residue moistened with concentrated sulphuric acid, which was kept at a temperature of 140° F. for eight hours, when a little water was added, and the mass filtered from a slight charred residue. The filtrate was made alkaline with strong ammonia and extracted with chloroform; the chloroform drawn off into a porcelain basin, and carefully evaporated so as to leave the residue as little distributed as possible; a few drops of concentrated sulphuric acid was added, when it was sufficiently colorless to test for strychnine with potassium bichromate. The reaction was *distinct*. When working with solutions containing ten times this quantity of strychnine, namely, 0·0025 gr., the reaction was *most* marked.

The above method has been tried many times with various quantities of strychnine and soup extract, and it has always been found that one treatment with concentrated sulphuric acid is sufficient to carbonize the foreign organic matter, which is never present in excessive quantities, and give a residue after filtration, etc., so slightly colored with sulphuric acid that it may at once be tested for strychnine. This is probably due to the jelly being already saturated with colloidal matter, and thus only allowing at the most traces of colloids to dialyze into it, whereas the crystalloids have free entry. With an ordinary parchment dialyzer comparatively large quantities of colloids do pass through.

Rodgers and Girwood's process as generally used—carbonizing with sulphuric acid, neutralizing with ammonia, extracting with chloroform, etc.—has frequently to be repeated many times before the extract is obtained sufficiently clean to be tested for strychnine and this part of the process requires much time and attention.

In the presence of large quantities of colloids the jelly does not swell so much, but the strychnine readily dialyzes into it.

A 1 per cent solution of gelose gives a good firm jelly, but at present I do not think that it works so satisfactorily as gelatin.

I hope shortly to carry the investigation further—with other alkaloids, metallic substances, etc. Experiments may prove that the time used for dialyzing can be considerably shortened.—*Chem. News.*

ON THE PROPORTIONS OF CARBONIC ACID IN THE HIGHER REGIONS OF THE ATMOSPHERE.

A. Muntz and E. Aubin have recently made determinations of the proportions of carbonic acid in the atmosphere both in the city of Paris and in the open country near Vincennes, the results of which agree with those of Reiset, showing that variations in the amount of carbonic acid only occur between very narrow limits, and are due to local influences; and, in general, that the carbonic acid is uniformly distributed throughout the lower strata of the atmosphere. They have continued their investigations upon the subject, and have applied their method of analysis to the air of elevated regions. Additional interest is lent to this part of their work from the fact that some recent investigations seem to indicate a decided diminution in the amount of carbonic acid in the air upon mountains. The method of analysis devised by them, and which has been found to be capable of giving extremely accurate results, consists essentially in drawing a measured volume of air through tubes filled with fragments of pumice-stone saturated with caustic potash. These tubes are sealed at both ends before the blowpipe, immediately at the close of each experiment, and the determination of the amount of carbonic acid absorbed may then be made in the laboratory after an indefinite time. The air was always drawn through metallic tubes from a distance of 8 to 10 meters to the windward side of the operator.

The point selected for carrying on the experiments was the summit of the Midi in the Pyrenees, at the altitude of 2,877 meters (9 422 ft.) above the level of the sea. This is an isolated peak distant from any other elevated summit; the air circulating about it is generally that of the upper currents of the atmosphere; and the great velocity of the wind dismisses any suspicion of local influence. During the course of the experiments the direction of the wind and the state of the atmosphere varied frequently; nevertheless, the proportion of carbonic acid in the air was found to be constant, the mean of a large number of observations giving 2·86 parts by volume of carbonic acid to 10,000 parts of air. This agrees very closely with the figure found in the experiments upon the plain at Vincennes (2·85). For the sake of comparison, experiments were made in two valleys at the foot of the Pyrenees, one near Pierrefitte (altitude 507 m.) and the other near Luz (altitude 730 m.) At the first station the result obtained was 2·79 volumes of carbonic acid to 10 000 parts of air, and at the second 2·69, the latter determination being made in the midst of a luxuriant vegetation. All the results obtained agree closely with those found in the lower regions of the atmosphere, and also with those found by Reiset and by Schultze in very varied situations.

As a result of their investigations MM. Muntz and Aubin consider themselves justified in stating that carbonic acid is uniformly distributed throughout the atmosphere, and that their results confirm the statements made by Reiset upon the subject and the theories of Schloesing in reference to the circulation of carbonic acid upon the surface of the globe.—*Comptes Rendus*, 93, 797.

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